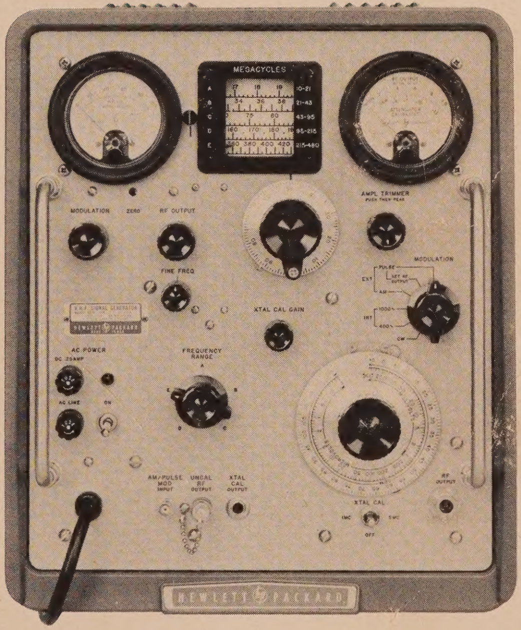
HP 608E

A. E. P. DEPT.
SCIENCE 2
LABORATORY

OPERATING AND SERVICE MANUAL

VHF SIGNAL GENERATOR
608E



HEWLETT hp PACKARD

HP 608E

CERTIFICATION

The Hewlett-Packard Company certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when it was shipped from the factory. The Hewlett-Packard Company further certifies that its calibration measurements are traceable to the U.S. National Bureau of Standards to the extent allowed by the Bureau's calibration facility.

WARRANTY AND ASSISTANCE

All Hewlett-Packard products are warranted against defects in materials and workmanship. This warranty applies for one year from the date of delivery, or, in the case of certain major components listed in the operating manual, for the specified period. We will repair or replace products which prove to be defective during the warranty period. No other warranty is expressed or implied. We are not liable for consequential damages.

For any assistance contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.

OPERATING AND SERVICE MANUAL

MODEL 608E
VHF SIGNAL GENERATOR

SERIALS PREFIXED: 543-

SEE APPENDIX
FOR OTHER SERIALS

Copyright HEWLETT-PACKARD COMPANY 1965
1501 PAGE MILL ROAD, PALO ALTO, CALIFORNIA, U.S.A.

02286-1

Printed: DEC 1965

TABLE OF CONTENTS

Section Page
I GENERAL INFORMATION 1-1
1-1. Description 1-1
1-4. Frequency 1-1
1-6. Modulation 1-2
1-10. Auxiliary Equipment 1-2
1-11. Model 11509A Fuseholder 1-2
1-13. Model 11508A Terminated Output Cable 1-3
1-15. Instrument Identification 1-3

II INSTALLATION 2-1
2-1. Incoming Inspection 2-1
2-3. Preparation for Use 2-1
2-4. Power Requirements 2-1
2-6. Power Cable 2-1
2-8. Repacking for Shipment 2-1

III OPERATION 3-1
3-1. Introduction 3-1
3-3. Controls, Indicators and Connectors 3-1
3-5. Basic Operating Procedures 3-1
3-6. Turn On 3-1
3-7. Crystal-Calibrator Operation . . 3-1
3-12. RF Output Loading 3-1
3-16. Fine Frequency Adjustment . . . 3-2
3-20. Operating Modes 3-2
3-22. CW Operation 3-2
3-24. Internal Sine-Wave Modulation 3-2
3-26. External Sine-Wave Modulation 3-7
3-28. Pulse Modulation 3-7
3-30. Uncalibrated RF Output 3-7

IV PRINCIPLES OF OPERATION 4-1
4-1. Introduction 4-1
4-3. Generator 4-1
4-10. The Attenuator 4-2
4-12. The Amplitude Modulation Section 4-2
4-14. Internal Sine-Wave Modulation . 4-2
4-23. External Sine-Wave Modulation 4-4
4-25. External Pulse Modulation 4-4
4-27. CW Operation 4-5
4-29. RF Output Meter Circuit 4-5
4-31. The Modulation Meter Section . . 4-5
4-36. The Calibrator Section 4-5
4-40. The Power Supplies 4-7
4-41. General Operating Principles . . 4-7
4-44. The +225 Volt Supply 4-8
4-46. The -165 Volt Supply 4-8
4-48. The +25 Volt Supply 4-8
4-50. The -6.3 Volt Supply 4-8

V MAINTENANCE 5-1
5-1. Introduction 5-1
5-3. Periodic Inspection 5-1
5-4. Cleaning 5-1

Section Page
V MAINTENANCE (Cont'd)
5-6. Lubrication 5-1
5-9. Performance Tests 5-1
5-10. Purpose 5-1
5-12. Test Equipment Required 5-1
5-14. Frequency Accuracy and Resettability Check 5-1
5-15. Calibrator Accuracy Check . . 5-4
5-16. Frequency-Drift Check 5-4
5-17. Residual FM Check 5-4
5-19. Maximum RF Output Check . . 5-5
5-20. Frequency Response and Leveling Check 5-5
5-21. RF Output Accuracy Check . . . 5-5
5-22. Uncalibrated RF Output Check 5-6
5-23. External Sine-Wave Modulation and Modulation-Meter Check 5-6
5-24. Internal Modulation Check . . . 5-7
5-25. Envelope Distortion Check . . . 5-7
5-26. Incidental FM Check 5-7
5-27. External Pulse-Modulation and Residual-Level Check 5-8
5-28. RF Leakage Check 5-8
5-29. Adjustment 5-9
5-30. Test Equipment Required 5-9
5-32. Power Supply Voltage Adjustment 5-9
5-35. Modulation Meter Adjustment . 5-10
5-38. Automatic Output Leveling Adjustment 5-10
5-39. RF Oscillator Adjustment . . . 5-10
5-40. Uncalibrated RF Output, Minimum RF Output, and RF Amplifier Tracking Adjustment . 5-10
5-41. RF Output Meter Accuracy Adjustment 5-11
5-44. RF Output Meter/Attenuator Frequency Response and Automatic-Leveling Output Adjustment . 5-11
5-45. Crystal Calibrator Adjustment 5-12
5-46. Troubleshooting 5-12
5-49. Isolating a Trouble to a Circuit Section 5-13
5-68. Isolating Trouble in Transistor Circuits 5-15
5-73. Etched Circuits 5-17
5-74. General Procedures 5-17
5-76. Component Replacement 5-17
5-77. Etched Conductor Repair 5-17
5-79. Transistor and Semiconductor Diode Replacement 5-17
5-80. Repair 5-18
5-81. Replacement of Electron Tubes 5-18
5-88. Attenuator Probe Repair and Replacement 5-21
5-97. Replacement of Lamp I1 5-23

VI REPLACEABLE PARTS 6-1
6-1. Introduction 6-1
6-3. Ordering Information 6-1
APPENDIX A-1

LIST OF ILLUSTRATIONS

Number	Title	Page
1-1.	Model 608E VHF Signal Generator	1-0
3-1.	Front Panel Controls, Connectors, and Indicators	3-0
3-2.	CW Operation	3-3
3-3.	Internal Sine-Wave Modulation	3-4
3-4.	External Sine-Wave Modulation	3-5
3-5.	Pulse Modulation	3-6
4-1.	Signal Generator	4-0
4-2.	RF Generator	4-1
4-3.	The Amplitude Modulation Section	4-3
4-4.	The Modulation Meter Section	4-5
4-5.	Calibrator Section Block Diagram	4-6
4-6.	Power Supply Block Diagram	4-7
5-1.	RF Tuner Drive Mechanism	5-2
5-2.	Fabrication of Test Equipment	5-2
5-3.	Frequency Accuracy and Resettability Test Setup	5-4
5-4.	Suggested Residual FM Test Setup	5-4
5-5.	RF Output Test Setup	5-5
5-6.	RF Output Accuracy Test Setup	5-6
5-7.	Uncalibrated RF Output Test Setup	5-6
5-8.	External Sine-Wave Modulation and Modulation-Meter Test Setup	5-6
5-9.	Envelope Distortion Test Setup	5-7
5-10.	Incidental FM Test Setup	5-8
5-11.	Pulse Modulation Test Setup	5-8
5-12.	RF Leakage Test Setup	5-8
5-13.	Location of Power Supply and Modulation-Meter Adjustments	5-9
5-14.	Location of Leveling and RF Output Meter Adjustments	5-10
5-15.	Location of RF Oscillator Adjustments	5-11
5-16.	Frequency-Response Adjustments	5-12
5-17.	Location of Frequency-Response and Crystal-Calibrator Adjustments	5-13
5-18.	Transistor Biasing and Operating Characteristics	5-16
5-19.	Location of Electron Tubes	5-18
5-20.	Replacement of Oscillator and Amplifier Tubes	5-20
5-21.	Disassembly of Attenuator Drive Cable	5-21
5-22.	Attenuator Probe, Showing Pickup Loop and Impedance Matching Network	5-22
5-23.	Notes Pertaining to Schematic and Voltage-Resistance Diagrams	5-24
5-24.	Voltage and Resistance Measurements	5-25
5-25.	Right Side View Showing Location of Unlabeled Chassis Components	5-28
5-26.	Rear View Showing Location of Unlabeled Chassis Components	5-29
5-27.	Left Side View Showing Location of Unlabeled Chassis Components	5-30
5-28.	RF Generator Assembly, Side Cover Removed, Showing Location of Parts	5-31
5-29.	RF Generator Assembly, Top Cover Removed, Showing Location of Parts	5-32
5-30.	RF Generator and Modulator Sections Schematic Diagram	5-33
5-31.	Modulation Meter and Crystal Calibration Sections Schematic Diagram	5-35
5-32.	Power Supply Schematic Diagram	5-37

LIST OF TABLES

Number	Title	Page
1-1.	Specifications	1-1
5-1.	Lubrication Chart	5-1
5-2.	Test Equipment Required for Performance Testing, Adjustment and Troubleshooting	5-3
5-3.	Out-of-Circuit Transistor Resistance Measurement	5-17
5-4.	Safe Ohmmeter Ranges for Transistor Resistance Measurements	5-17
5-5.	Etched Circuit Soldering Equipment	5-18
5-6.	Checks Following Tube and Semiconductor Replacement	5-19
6-1.	Reference Designation Index	6-2
6-2.	Replaceable Parts	6-11

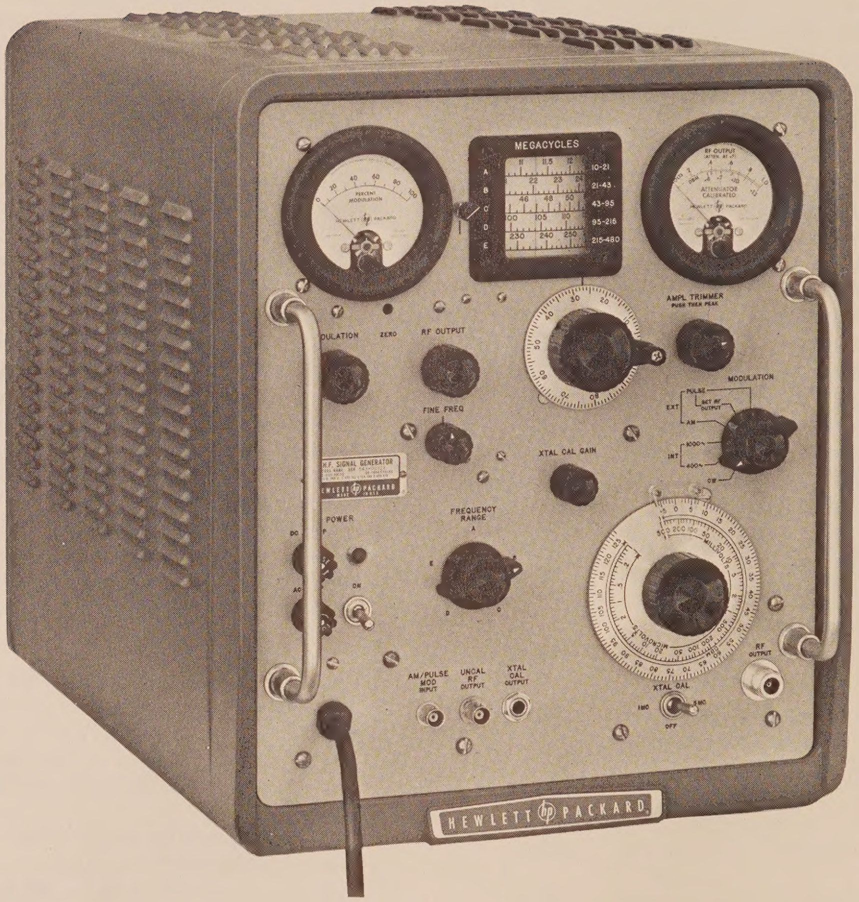


Figure 1-1. Model 608E VHF Signal Generator

SECTION I
GENERAL INFORMATION

1-1. DESCRIPTION.

1-2. The Hewlett-Packard Model 608E VHF Signal Generator furnishes RF signals from 0.1 microvolt to 1 volt over the frequency range from 10 to 480 megacycles. The signals may be amplitude modulated by internally generated sine waves or by externally applied sine waves or pulses. Detailed specifications for the Model 608E are given in Table 1-1.

1-3. The Model 608E Signal Generator is designed to meet the requirements of precision laboratory work and yet to be equally useful for general applications in the 10- to 480-megacycle frequency range. The equipment can be used for testing, calibrating, and troubleshooting VHF radio equipment and circuits, and for measuring standing-wave ratios, antenna and transmission line characteristics, receiver sensitivity. To preserve accuracy, care has been taken to hold spurious modulation to a low value under all operation conditions.

1-4. FREQUENCY.

1-5. The frequency of the output signal is indicated on a direct-reading dial, the calibration of which is accurate to better than ±0.5% when the cursor and FINE FREQ adjustments are properly aligned. Calibration accuracy may be improved further by use of a built-in crystal-controlled heterodyne calibrator which furnishes 1-Mc or 5-Mc checkpoints over the entire frequency range of the instrument. At any

Table 1-1. Specifications

FREQUENCY

Range: 10-480 Mc in 5 bands, 10-21, 21-43, 43-95, 95-215, and 215-480 Mc.

Accuracy: ±0.5%

Drift: Less than 50 parts in 10^6 per 10 minute period after one hour warmup. Less than 10 minutes to restabilize after changing frequency.

Tuning Control: Frequency control mechanism provides a main dial calibrated in megacycles and a vernier dial for interpolation purposes. Total scale length: Approximately 45 inches. Calibration: Every other megacycle 130 to 270 Mc; every 5 Mc above 270 Mc.

Resettability: Main frequency control resettability better than ±0.1% after initial warmup. Fine Frequency Adjust provides approximately 25 kc settability at 480 Mc. (Proportionately finer adjustment at lower frequencies.)

Crystal Calibrator: Provides frequency check points every 1 Mc or 5 Mc over the range of the instrument. Headphone jack provided for audio frequency output (headphones not included). Crystal frequency accuracy better than 0.01% at normal room temperatures. Cursor on frequency dial adjustable over small range to aid in interpolation adjustment. Calibrator may be turned off when not in use.

Residual FM: Less than 5 parts in 10^7 peak.

Harmonic Output: At least 35 db below the carrier.

OUTPUT CHARACTERISTICS

Output Level: Continuously adjustable from 0.1μ volt to 1.0 volt into a 50 ohm resistive load. Output attenuator calibrated in volts and dbm. (0 dbm = 1 mw in 50 ohms).

Accuracy: Within ±1 db of attenuator dial reading at any frequency when RF Output Meter indicates "ATTENUATOR CALIBRATED".

Leveling: Internal feedback circuit retains "ATTENUATOR CALIBRATED" reference on RF Output Meter over wide frequency ranges (typically octave bands). When carrier frequency changed, adjustment of front panel AMP. TRIMMER control (only) for maximum RF output indication automatically restores initial carrier level (and initial modulation percentage if frequency changed while amplitude modulated).

Impedance: 50 ohms with a maximum SWR of 1.2 for attenuator setting below -7 dbm.

RFI: Conducted and radiated leakage limits are below those specified in MIL-I-6181D; permits receiver sensitivity measurements down to at least 0.1 microvolt.

Auxiliary RF Output: Fixed Level CW signal from RF Oscillator (minimum amplitude 180 mv into 50 ohms) provided at front panel BNC female connector for use with external equipment (e.g., frequency counter).

Table 1-1. Specifications (Cont'd)

MODULATION CHARACTERISTICS

(Front panel AMP TRIMMER control adjusted for maximum indication on RF Output Meter)

Internal AM

Frequency: 400 and 1000 cps, ±10%. Modulation signal available at front panel BNC female connector for synchronization of external equipment.

Modulation Level: 0 to 95% modulation at carrier levels of 0.5 volt and below; continuously adjustable with front panel MOD LEVEL control.

Carrier Envelope Distortion: Less than 2% at 30% AM and less than 3% at 80% AM.

External AM

Frequency: 20 cps to 20 kc.

Modulation Level: 0 to 95% modulation at carrier levels of 0.5 volt and below; continuously adjustable with front panel MOD LEVEL control. Input required: 1-10 volts, rms, (1Ω input impedance).

Carrier Envelope Distortion: Less than 1% at 30% AM, less than 3% at 80% AM (modulation source less than 0.5% distortion).

External control of carrier level can be achieved through application of DC voltage in EXT AM mode.

Modulation Meter

Accuracy: ±5% of full scale 0 to 80%. ±10% from 80% to 95% (for INT AM or 20 cps to 20 kc EXT AM).

Incidental Frequency

Modulation: Less than 1000 cps peak at 50% AM for frequencies above 100 Mc. For frequencies below 100 Mc, less than 0.001% at 30% AM.

External Pulse Modulation

Rise and Decay Time: From 40 Mc to 220 Mc, combined rise and decay time less than 4 μsec. From 220 Mc to 480 Mc, combined rise and decay time less than 2μsec.

On-Off Ratio: At least 20 db for pulsed carrier levels above 0.5 volt.

Input Required: Positive pulse, 10-50 volts peak; input impedance 2 k ohm.

GENERAL

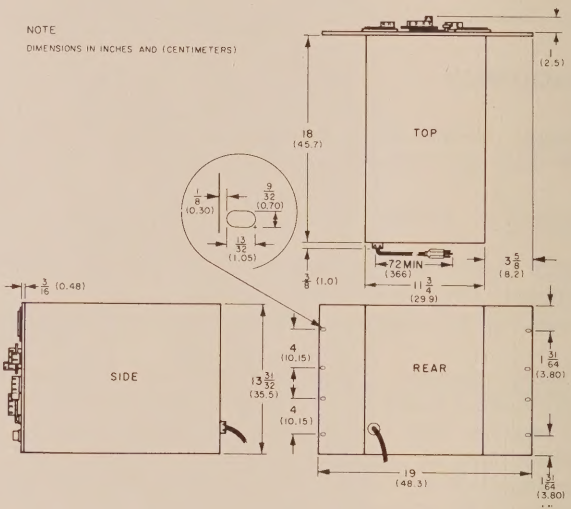
Power: 115 or 230 volts ±10%, 50 to 400 cps. Approximately 220 watts.

Dimensions:
Cabinet Mount: 13-1/4 in. (33,7 cm) wide, 16-3/4 in. (41,6 cm) high, 21 in. (53,3 cm) deep.

Rack Mount:

Weight:
Cabinet Mount: Net, 62 lbs. (28 kg). Shipping 73 lbs. (33 kg).

Rack Mount: Net, 62 lbs. (28 kg). Shipping, 89 lbs. (40 kg).



NOTE
DIMENSIONS IN INCHES AND (CENTIMETERS)

Accessories Available:

11508A Output Cable provides 50 ohms termination and standard binding posts at the end of a 24-inch (61 cm) length of cable. Allows direct connection of the signal generator to high impedance circuits.

11509A Fuse Holder provides protection of the attenuator elements when the 608 is used for transceiver tests.

10514A Mixer for fast pulsing.

checkpoint the calibration can be set very close to the calibrator accuracy of 0.01%, bringing overall accuracy to at least ±0.05%. Frequency checkpoint signals are obtained when a headphone set (not furnished) is plugged into the XTAL CAL OUTPUT jack. The control for the output attenuator is calibrated in both decibels and volts. When the 608E is connected to a 50-ohm resistive load and power into the output attenuator is exactly at the ATTENUATOR CALIBRATED mark (+7 db) on the RF OUTPUT meter, the level of power or voltage applied to the RF OUTPUT connector may be read directly on the ATTENUATOR dial with an accuracy of ±1 db. When connected to a 50-ohm resistive load, the VSWR at the RF OUTPUT connector will not be greater than 1.2 (SWR of 1.6 db). The Model 608E features automatic output leveling, maintaining the RF output within ±1 db of the adjusted output. An uncalibrated-voltage RF output is provided for driving an external counter.

1-6. MODULATION.

1-7. The RF output signal can be amplitude modulated by internally generated 400- and 1000-cycle sine waves, externally applied sine waves above 1.0 volt rms over the frequency range from 20 cps to 100 kc, or externally applied pulses of 10 volts peak-to-peak. When pulse modulated, the 608E is capable of producing pulses of RF energy as short as 4 microseconds at signal frequencies above 40 megacycles and pulses as short as 2 microsecond above 220 megacycles. The degree of sine-wave modulation is continuously variable from 0 to 90% by a front-panel control. All sine-wave modulation of the output signal is continuously monitored and indicated in percentage on a direct reading modulation meter.

1-8. RFI.

1-9. RF leakage is held to a minimum and is such that when the output signal is adjusted for 0.1 microvolt, the conducted signal leakage at any other front panel connector and the radiated leakage two inches from the instrument are each less than 1.0 microvolt.

1-10. AUXILIARY EQUIPMENT.

1-11. MODEL 11509A FUSEHOLDER.

1-12. To protect the output attenuator from damage, for some applications (such as transceiver testing) it is desirable to insert a fuse between the 608E and external equipment. The 11509A is a special coaxial fuseholder which houses a type 8AG, 1/16 amp fuse which protects the output attenuator from damage in the event that an external voltage is accidently applied to the RF OUTPUT connector. The fuseholder has an insertion loss of 0.50 db at 200 Mc, 0.56 db at 300 Mc, and 0.65 db at 400 Mc; its SWR is not greater than 1.35 when connected to a 50-ohm resistive load.

1-13. MODEL 11508A TERMINATED OUTPUT CABLE.

1-14. This cable assembly provides a 50-ohm termination and standard binding posts at the end of a 24-inch length of cable. The 11508A allows direct connection of the 608E to a high-impedance circuit.

1-15. INSTRUMENT IDENTIFICATION.

1-16. Hewlett-Packard instruments carry a two-section, eight-digit serial number. The first three digits are a prefix. The contents of this manual apply to those instruments having the serial number prefix shown on the title page. If the serial prefix on your instrument is not mentioned on the title page, in the Appendix to this manual, or in a Manual Change Sheet enclosed with the manual, the correct information may be obtained from any Hewlett-Packard Sales and Service Office (see rear of manual for addresses).

SECTION II
INSTALLATION

2-1. INCOMING INSPECTION.

2-2. This instrument was inspected mechanically and electrically prior to shipment. Inspect for mechanical damage received in transit and test electrical performance using the procedure given in Paragraph 5-9. If there is damage or deficiency, or if electrical performance is not within specifications, notify the carrier and your Hewlett-Packard Sales and Service Office immediately (see list at rear of this manual.)

2-3. PREPARATION FOR USE.

2-4. POWER REQUIREMENTS.

2-5. The VHF Signal Generator requires a power source of 115 or 230 volts ac ±10%, single phase, which can supply approximately 220 watts. A two-position slide switch, on the inside rear chassis, permits operation from either a 115- or 230-volt power source. The number visible on the switch slider indicates the line voltage for which the Signal Generator is connected. Adjacent to the switch is the correct fuse rating for each line voltage. To prepare the Signal Generator for operation, position the 115-230 volt switch so that the number visible on the slider corresponds to the available line voltage, and install a fuse of correct rating (marked on rear apron).

CAUTION

> Before connecting the power cable, set the 115-230 volt switch for the line voltage to be used.

2-6. POWER CABLE.

2-7. To protect operating personnel, the National Electrical Manufacturers' Association (NEMA) recommends that the instrument panel and cabinet be grounded. This instrument is equipped with a three-conductor power cable which, when plugged into an appropriate receptacle, grounds the instrument. The off-set pin of the three-prong connector is the ground pin. To preserve the protection feature when operating the instrument from a two-contact outlet, use a three-prong to two-prong adapter (Hewlett-Packard Stock No. 1251-0048) and connect the green pigtail on the adapter to ground.

2-8. REPACKING FOR SHIPMENT.

2-9. If the Signal Generator is to be packaged for shipment use the original shipping container and packing materials. If these have been discarded or are not in condition for reuse, obtain new materials from your local Hewlett-Packard Sales and Service Office (see rear of this manual for locations), or follow these general instructions:

a. Wrap the Signal Generator in heavy paper or plastic. (If the Signal Generator is being shipped to a Hewlett-Packard service facility, attach a tag indicating type of servicing required, return address, model number, and full serial number.)

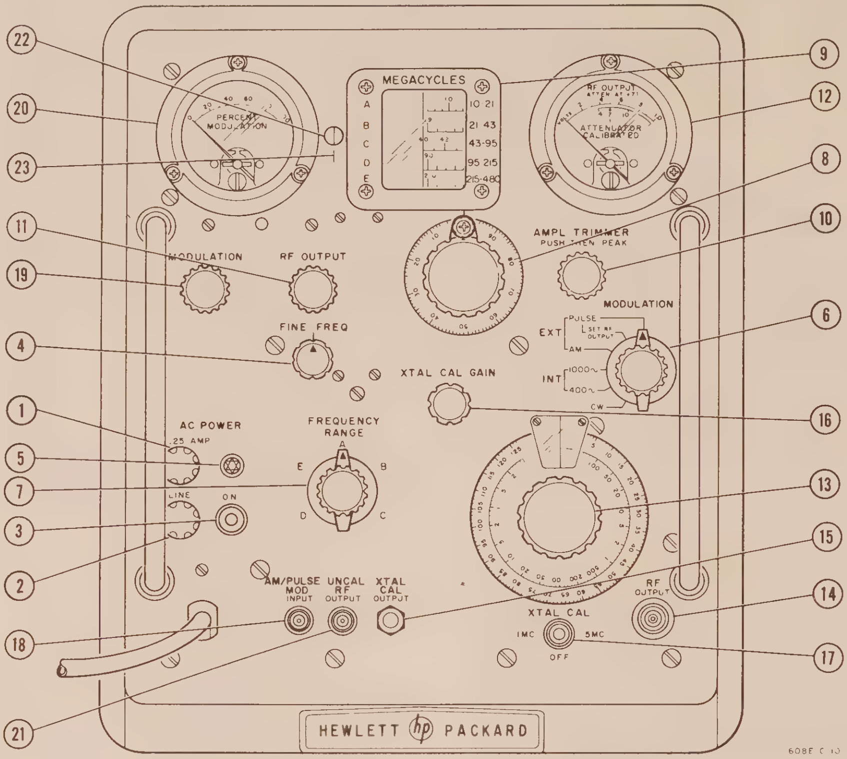
b. Use a strong shipping container. A carton made of 500-600 pound test material will usually provide adequate protection.

c. Use enough shock-absorbing material (3 to 4 inch layer) around all sides of instrument to provide firm cushion and prevent movement inside the container. Protect the control panel with cardboard. With Hewlett-Packard "floater pack" packaging, the foam blocks provide sufficient shock protection, and additional material is unnecessary.

d. Seal the shipping container securely.

e. Mark the shipping container "FRAGILE" to assure careful handling.

2-10. In any correspondence refer to the Signal Generator by model number and full serial number.



1. DC 0.25 AMP: Protects the internal dc power supply against short circuits in the instrument.
2. AC LINE: Protects instrument against short circuits.
3. Power Switch: In the ON position, power from the line is applied to the primary of the power transformer.
4. FINE FREQ: Vernier for frequency control.
5. Pilot lamp: Lights when ac power is applied.
6. MODULATION: Sets modulation mode.
7. FREQUENCY RANGE: Selects tuned circuits for desired frequency range, and positions range pointer on MEGACYCLES dial.
8. Frequency control: Selects output frequency in conjunction with FREQUENCY RANGE switch.
9. MEGACYCLES: Indicates the frequency of the RF output signal directly in megacycles.
10. AMPL TRIMMER: A push-to-tune control. Tunes RF power amplifier for maximum output as indicated on output meter.
11. RF OUTPUT (control): Adjusts level of RF power at input to attenuator.
12. RF OUTPUT (meter): Indicates level of RF power applied to attenuator
13. Attenuator control: Adjusts and indicates RF output level in microvolts, millivolts, and DBM.
14. RF OUTPUT: Output connector for calibrated RF signal. (See CAUTION, para 3-6)
15. XTAL CAL OUTPUT: Crystal calibrator output; accommodates earphone plug.
16. XTAL CAL GAIN: Adjusts loudness of beat-frequency signal obtained from XTAL CAL OUTPUT jack.
17. XTAL CAL 1MC-OFF-5MC: Selector switch for crystal calibrator.
18. AM/PULSE MOD INPUT: Receives sine wave or pulse from external source for modulation of RF output signal. When using internal modulation, the 400- or 1000-cps sine-wave modulating signal is present at this connector for use as a synchronization signal.
19. MODULATION: Adjusts modulation percentage to desired value (percent of modulation indicated on modulation meter).
20. PERCENT MODULATION: Indicates percent of modulation of RF output signal.
21. UNCAL RF OUTPUT: Output connector for uncalibrated RF output signal for monitoring on frequency counter, etc.
22. Cursor knob: Cursor adjustment; positions cursor on dial.
23. Panel marker: Panel marker for cursor alignment.

Figure 3-1. Front Panel Controls, Connectors, and Indicators

SECTION III

OPERATION

3-1. INTRODUCTION.

3-2. This section provides a complete description of the Signal Generator operating controls and the methods to properly operate the Signal Generator.

3-3. CONTROLS, INDICATORS & CONNECTORS.

3-4. Except for the 115/230 volt power switch, all controls, indicators, and connectors are located on the front panel. Figure 3-1 shows the location and provides a functional description of each control, indicator, and connector.

3-5. BASIC OPERATING PROCEDURES.

3-6. TURN ON.

CAUTION

Do not obstruct the ventilating louvers on the sides of the instrument cabinet. Safe operating temperature depends on free air flow through these louvers.

a. Check that the power switch is in the off position, and check 115-230 volt switch (see paragraph 2-5).

b. Place MODULATION selector in the CW position and the RF OUTPUT control to near maximum (clockwise). Other controls may be set in any position before turning generator on.

c. Set power switch to ON. The power pilot lamp should light.

d. Allow equipment to heat for 10 minutes before use. If greatest frequency stability is required, allow equipment to heat for 60 minutes.

CAUTION

Do not connect any source of RF or dc power to RF OUTPUT jack on Signal Generator. To do so may permanently damage impedance-matching network in output attenuator. Special care must be observed when testing transceiver-type equipments, to insure that the transmitter remains inoperative while connected to the Signal Generator.

Note

For protection of the output attenuator in the Signal Generator, a special fuseholder (Model 11509A) is available for connection to the RF OUTPUT connector. When using the Signal Generator for any application where there is the possibility of voltage being applied to the RF OUTPUT connector, this fuse may be used between the output connector and the test cable connecting the Signal Generator to the external equipment.

3-7. CRYSTAL-CALIBRATOR OPERATION.

3-8. The frequency (MEGACYCLES) dial in the Model 608E is calibrated to be accurate within ±0.5%. To obtain higher accuracy, a crystal-controlled calibrator has been included to provide the operator with a means for setting the MEGACYCLES dial calibration on-frequency at any multiple of 1 or 5 megacycles over the entire frequency range of the Signal Generator. To use the calibrator, a standard 600-ohm head-phone (not furnished) is required. The XTAL CAL OUTPUT jack accommodates a telephone-type two-contact plug.

3-9. The calibrator provides either a 1-Mc or a 5-Mc signal accurate to 0.01%. By heterodyning this signal with the output frequency a beat-frequency check point is produced at every integral multiple of 1 or 5 megacycles. On-frequency appears as a zero beat.

3-10. For best accuracy the MEGACYCLES dial should be set on the calibration line nearest the frequency to be used. The MEGACYCLES dial cursor can be adjusted a small amount each side of center by means of the cursor adjustment to the left of the MEGACYCLES dial.

3-11. A volume control, XTAL CAL GAIN, is provided for adjusting the level of the audio voltage applied to the headphone.

3-12. RF OUTPUT LOADING.

3-13. A resistive load of 50 ohms is used during calibration of the 608E output attenuator dial. Therefore, for accurate indication of output power, the external load should be 50 ohms, resistive. The internal impedance of the generator is very close to 50 ohms. A maximum VSWR of 1.2 exists when the generator is terminated in 50 ohms. This magnitude of VSWR will have no important effect on the accuracy of attenuator dial calibration. However, if the value of the load is not known and if best accuracy in measurements is desired, it is necessary that the standing-wave ratio in the line to the load be minimized.

3-14. Table 3-1 shows the calculated power loss when the load on the Signal Generator causes a voltage standing wave ratio of the magnitude shown. The VSWR values shown are a comparison between a load and a 50-ohm transmission line. The minimum loss figures are based on a mismatch of 1.2 VSWR between the Signal Generator and transmission line. Mismatches causing the voltage standing wave ratios given in the left-hand column will result in power losses somewhere between the limits shown in the other two columns. The maximum loss shown is the total loss from the maximum power available from the generator for a given setting of the output attenuator and includes a generator VSWR of 1.2. The data does not allow for transmission-line-to-load losses; in most cases such losses are small enough to be unimportant. When the load is matched to the transmission line (VSWR = 1.0) the loss from the maximum power available from the Signal Generator is 0.06 db. Although the losses, as shown in db, are not great numerically, it should be noted that they may represent a considerable difference between the voltage calibration of the output attenuator dial and the actual voltage impressed across the external load.

Table 3-1. VSWR Versus Power Loss

VSWR In 50-Ohm Line	Min. Power Loss (db)	Max. Power Loss (db)
1.0	.06	0.06
1.5	.08	.37
2.0	.3	.85
2.5	.6	1.3
3.0	.9	1.7
4.0	1.5	2.4
5.0	2.0	3.1

3-15. In most cases when making measurements on receivers designed to work from a 50-ohm line and antenna, the standing-wave ratio in the line from the Signal Generator to the receiver is not significant. The reason for this is that any power reflected from the receiver back towards the generator represents a deficiency in receiver design, and the amount of power lost in such cases is considered as a loss subtractive from the gain of the receiver. A factor which contributes error in high-frequency measurements is the improper assembly of coaxial connectors. A standing wave ratio of several db can often be attributed to this cause.

3-16. FINE FREQUENCY ADJUSTMENT.

3-17. The Model 608E is equipped with a short-range incremental tuning device (FINE FREQ) for making extremely small changes in the output signal frequency. The fine frequency adjustment is operated at the front panel by a small knob to the left of the main frequency control knob. When the arrow on the knob points to the left, the frequency is minimum; when the arrow points to the right, the frequency is maximum. The main frequency dial calibration is accurate when the arrow is aligned with the dot on the front panel.

3-18. When the Signal Generator is operated at the high ends of the frequency ranges and when the finest possible control of frequency is required, adjust the main frequency control very close to the desired frequency with the vernier set slightly below maximum frequency (arrow pointing to right) and then adjust the vernier control for the exact desired frequency. When operating at the low ends of the frequency ranges the effectiveness of the vernier is decreased and must be used near its minimum frequency setting (arrow at left).

3-19. The RF output is automatically leveled within ±1 db at an RF output of 0.5 volt or less with proper adjustment of the AMPL TRIMMER control in all operating modes but external pulse operation. When using CW, internal sine-wave modulation, external sine-wave modulation, and when adjusting for pulse operation (MODULATION selector at PULSE/SET RF OUTPUT), the RF OUTPUT meter must be adjusted for a maximum indication on the RF OUTPUT meter. If operation is restricted to a relatively small area of a band or a single frequency, the AMPL TRIMMER shoud be peaked at the center of the area or on-frequency, respectively. When using the entire band on bands A, B, C, and D, the AMPL TRIMMER should be peaked at the lower end of the band, and as the frequency in use progresses up the band, the RF OUTPUT meter observed for deviation from +7 db (ATTEN CALIBRATED). If the meter deviates, without depressing the AMPL TRIMMER, adjust in direction necessary to return RF OUTPUT meter to +7 db. When using the entire band on band D, two adjustments must be made; one at the low end of the band and one at the middle of the band. As with the lower frequency bands the AMPL TRIMMER should be adjusted (without depressing) just enough to return the RF OUTPUT meter to +7 db as the frequency in use increases.

3-20. OPERATING MODES.

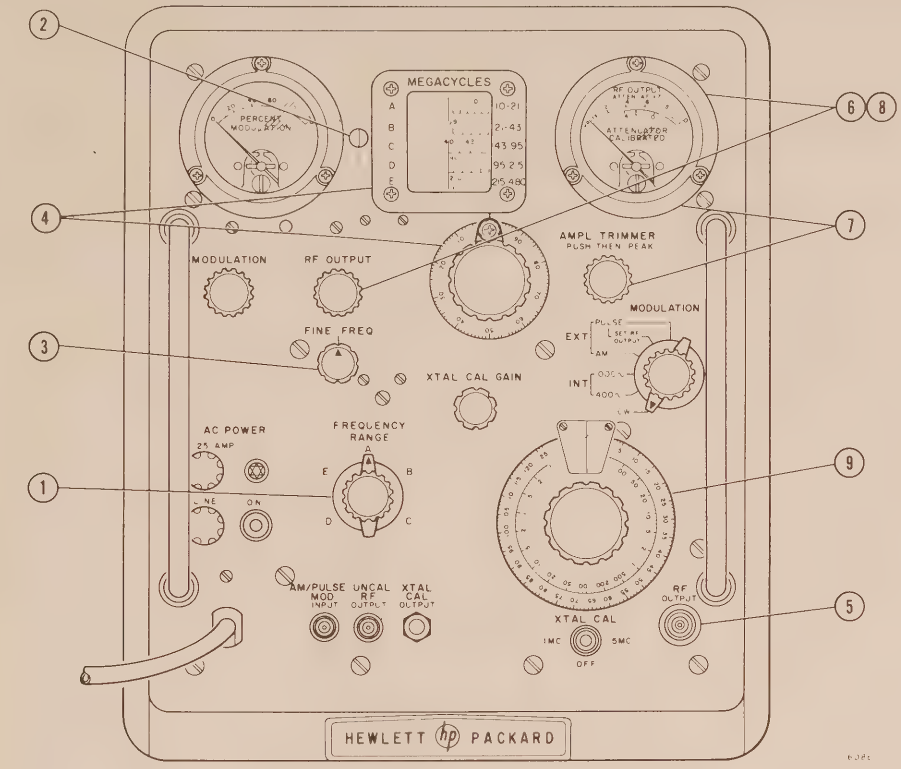
3-21. The Signal Generator has four operating modes, which are designated CW operation, internal sine-wave operation, external sine-wave operation, and pulse modulation.

3-22. CW OPERATION.

3-23. When operated in the CW mode the Signal Generator delivers an unmodulated RF output, the level of which is established by the control adjustments (see paragraph 3-19). Instructions for CW operation are given in Figure 3-2.

3-24. INTERNAL SINE-WAVE MODULATION.

3-25. The Model 608E provides facilities for 400- or 1000-cycle modulation of the RF signal. The modulating frequencies are accurate to within ±10%, and envelope distortion is less than 2% for modulation percentages to 30%. The percent modulation is continuously adjustable from 0 to 90% by the MODULATION control and is read directly from the PERCENT MODULATION meter to within ±5% of full scale at 10% to 90% modulation. Incidental frequency modulation resulting from amplitude modulation of the output signal is extremely low, being less than 1000 cycles for



Note

Perform turn-on procedure described in paragraph 3-6.

1. Set **FREQUENCY RANGE** to proper range. (Frequency limits of each range shown on MEGACYCLES dial housing.)

2. Align cursor adjustment with panel alignment marker.

3. Align **FINE FREQ** control with panel alignment marker.

4. Adjust frequency control to align MEGACYCLES dial cursor with desired frequency.

Note

For maximum frequency accuracy, see crystal-calibrator operation and fine frequency adjustment, paragraph 3-7 and 3-16, respectively

5. Connect equipment under test to **RF OUTPUT** connector.

CAUTION

Do not connect any source of RF or dc power to RF OUTPUT jack on Signal Generator. To do so may permanently damage impedance-matching network in output attenuator. Special care must be observed when testing transceiver-type equipments, to insure that the transmitter remains inoperative while connected to the Signal Generator.

6. Adjust **RF OUTPUT** control to obtain an indication on **RF OUTPUT** meter

7. Depress and adjust **AMPL TRIMMER** for maximum indication on **RF OUTPUT** meter. (See paragraph 3-19.)

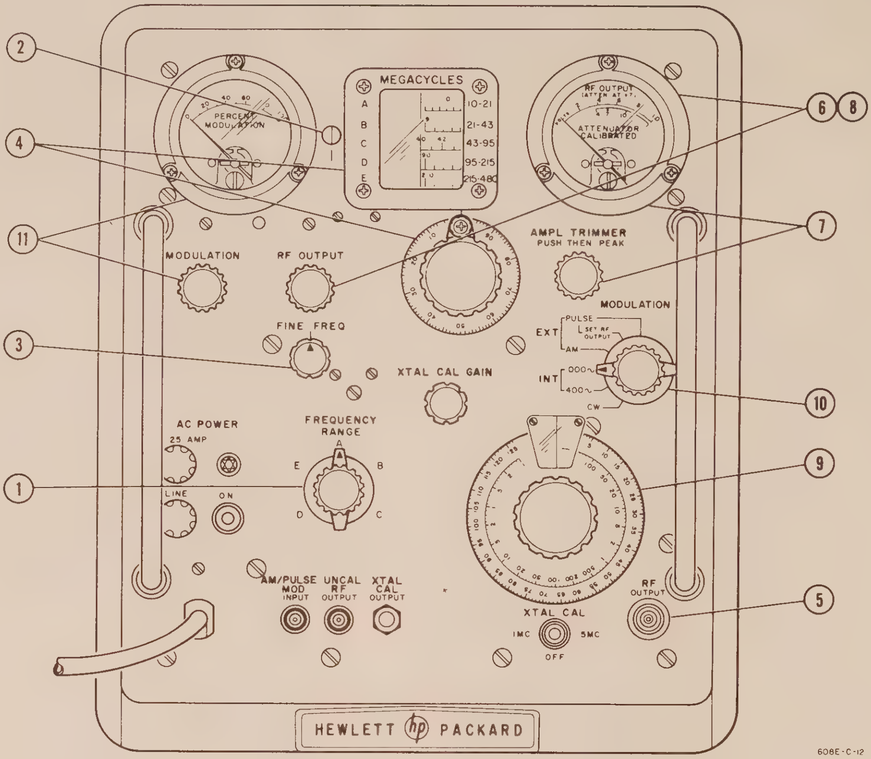
8. Readjust **RF OUTPUT** control until **RF OUTPUT** meter pointer is aligned with **ATTENUATOR CALIBRATED** (+7 db) mark.

9. Adjust attenuator dial for desired output level.

Note

Accuracy of attenuator dial setting and PERCENT MODULATION meter are within specifications only when RF OUTPUT meter is indicating ATTENUATOR CALIBRATED.

Figure 3-2. CW Operation



Note

Perform turn-on procedure described in paragraph 3-6.

1. Set FREQUENCY RANGE to proper range. (Frequency limits of each range shown on MEGACYCLES dial housing.)
2. Align cursor adjustment with panel alignment marker.
3. Align FINE FREQ control with panel alignment marker.
4. Adjust frequency control to align MEGACYCLES dial cursor with desired frequency.

Note

For maximum frequency accuracy, see crystal-calibrator operation and fine frequency adjustment, paragraph 3-7 and 3-16, respectively.

5. Connect equipment under test to RF OUTPUT connector.

CAUTION

Do not connect any source of RF or dc power to RF OUTPUT jack on Signal Generator. To do so may permanently damage impedance-matching network in output attenuator. Special care must be observed when testing transceiver-type equipments, to insure that the transmitter remains inoperative while connected to the Signal Generator.

6. Adjust RF OUTPUT control to obtain an indication on RF OUTPUT meter.
7. Depress and adjust AMPL TRIMMER for maximum indication on RF OUTPUT meter (see paragraph 3-19).
8. Readjust RF OUTPUT control until RF OUTPUT meter pointer is aligned with ATTENUATOR CALIBRATED (+7 db) mark.
9. Adjust attenuator dial for desired output level.

Note

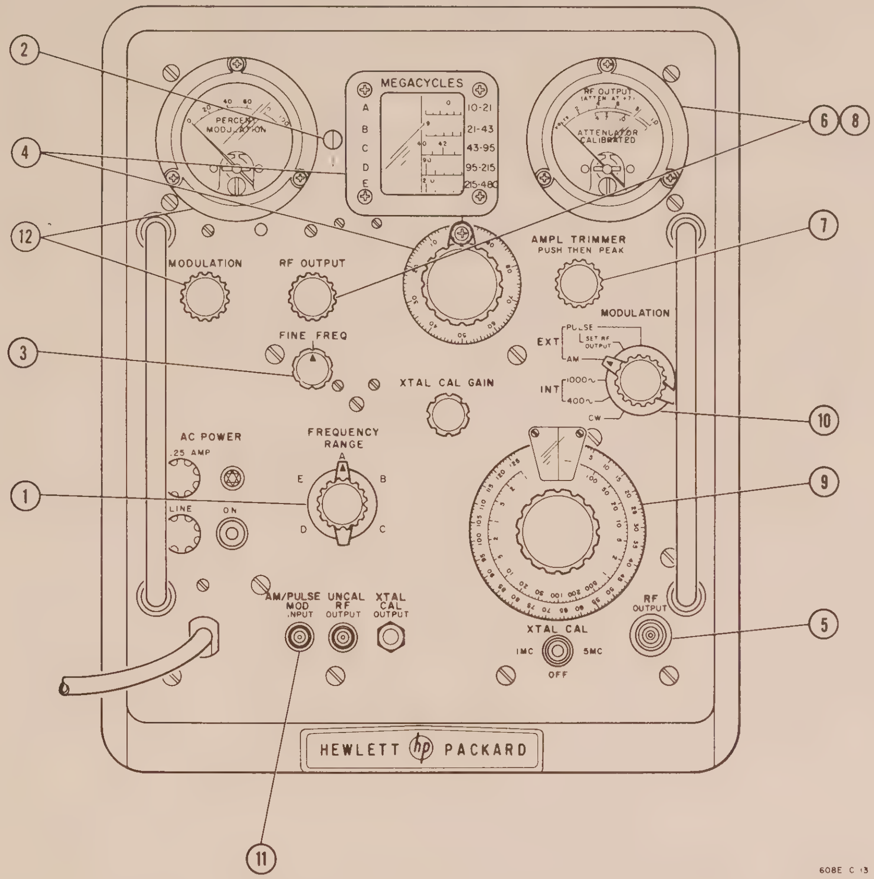
Accuracy of attenuator dial setting and PERCENT MODULATION meter are within specifications only when RF OUTPUT meter is indicating ATTENUATOR CALIBRATED.

10. Set MODULATION selector to 400 ~ or 1000 ~, as desired.
11. Set MODULATION control for degree of modulation as shown by PERCENT MODULATION Meter.

Note

At high modulation levels the RF OUTPUT meter indication may change. If so, reset RF output to ATTENUATOR CALIBRATED with RF OUTPUT control.

Figure 3-3. Internal Sine-Wave Modulation



Note

Perform turn-on procedure described in paragraph 3-6.

1. Set FREQUENCY RANGE to proper range. (Frequency limits of each range shown on MEGACYCLES dial housing.)
2. Align cursor adjustment with panel alignment marker.
3. Align FINE FREQ control with panel alignment marker.
4. Adjust frequency control to align MEGACYCLES dial cursor with desired frequency.

Note

For maximum frequency accuracy, see crystal-calibrator operation and fine frequency adjustment, paragraph 3-7 and 3-16, respectively.

5. Connect equipment under test to RF OUTPUT connector.

CAUTION

Do not connect any source of RF or dc power to RF OUTPUT jack on Signal Generator. To do so may permanently damage impedance-matching network in output attenuator. Special care must be observed when testing transceiver-type equipments, to insure that the transmitter remains inoperative while connected to the Signal Generator.

6. Adjust RF OUTPUT control to obtain an indication on RF OUTPUT meter.
7. Depress and adjust AMPL TRIMMER for maximum indication on RF OUTPUT meter (see paragraph 3-19).
8. Readjust RF OUTPUT control until RF OUTPUT meter pointer is aligned with ATTENUATOR CALIBRATED (+7 db) mark.
9. Adjust attenuator dial for desired output level.

Note

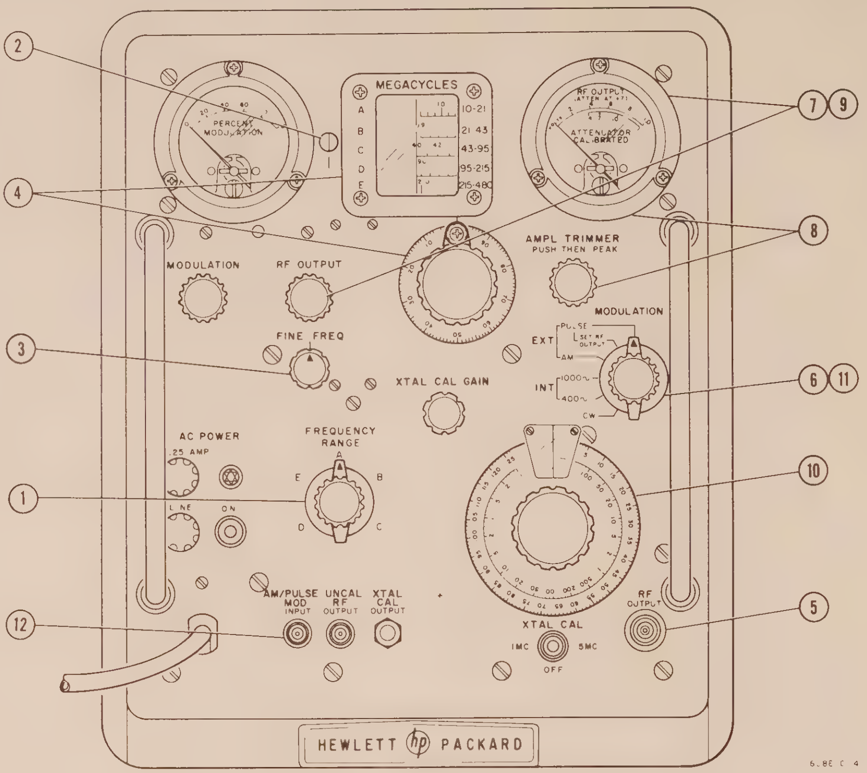
Accuracy of attenuator dial setting and PERCENT MODULATION meter are within specifications only when RF OUTPUT meter is indicating ATTENUATOR CALIBRATED.

10. Set MODULATION selector to AM.
11. Connect modulating source to AM/PULSE MOD INPUT connector.
12. Set MODULATION control for desired degree of modulation on PERCENT MODULATION meter.

Note

At high modulation levels the RF OUTPUT meter indication may change. If so, reset RF output to ATTENUATOR CALIBRATED with RF OUTPUT control.

Figure 3-4. External Sine-Wave Modulation



Note

Perform turn-on procedure described in paragraph 3-6.

1. Set FREQUENCY RANGE to proper range. (Frequency limits of each range shown on MEGACYCLES dial housing.)

2. Align cursor adjustment with panel alignment marker.

3. Align FINE FREQ control with panel alignment marker.

4. Adjust frequency control to align MEGACYCLES dial cursor with desired frequency.

Note

For maximum frequency accuracy, see crystal-calibrator operation and fine frequency adjustment, paragraph 3-7 and 3-16, respectively.

5. Connect equipment under test to RF OUTPUT connector.

CAUTION

Do not connect any source of RF or dc power to RF OUTPUT jack on Signal Generator. To do so would permanently damage impedance-matching network in output attenuator. Special care must be observed when testing transceiver-type equipments, to insure that the transmitter remains inoperative while connected to the Signal Generator.

6. Set MODULATION selector to PULSE/SET RF OUTPUT.

7. Adjust RF OUTPUT control to obtain an indication on RF OUTPUT meter.

8. Adjust AMPL TRIMMER for maximum indication on RF OUTPUT meter.

9. Readjust RF OUTPUT control until RF OUTPUT meter pointer is aligned with ATTENUATOR CALIBRATED (+7 db) mark.

10. Adjust attenuator dial for desired output level.

Note

Accuracy of attenuator dial setting and PERCENT MODULATION meter are within specifications only when RF OUTPUT meter is indicating ATTENUATOR CALIBRATED.

11. Set MODULATION selector to PULSE.

12. Connect modulating source to AM/PULSE MOD INPUT connector.

Figure 3-5. Pulse Modulation

reasonable modulation percentages. For modulation percentages below 50%, the frequency modulation index will not exceed 1.0. Output frequency and power level (see paragraph 3-19) are set in the same manner as for CW operation except that the selector is set to 400~ or 1000~. Instructions for using internal sine-wave operations are given in Figure 3-3. This modulation is also available as a 2 VRMS signal from a 100 K ohm source at the front panel AM/PULSE MOD INPUT jack for synchronism of external equipment.

3-26. EXTERNAL SINE-WAVE MODULATION.

3-27. Externally supplied signals in the range of 20 to 20,000 cps and above, with an amplitude of approximately 1.0 volt across 1000 ohms, may be used to modulate the RF signal. The degree of modulation is continuously adjustable and is indicated directly on the front panel meter. Figure 3-4 gives instructions for external sine-wave modulation operation. External control of carrier level can be achieved through application of DC voltage in EXT AM mode. This makes possible remote control of carrier output. When the RF OUTPUT meter is set on the ATTENUATOR CALIBRATED (+7 DB) mark a voltage of +15 to -15 volts fed into the AM/PULSE MOD INPUT jack will vary the output from full on to full off. This jack has an input impedance of 5 K ohms when the MODULATION jack is fully clockwise.

3-28. PULSE MODULATION.

3-29. Externally supplied positive pulses above 10 peak-to-peak volts may be used to pulse modulate the RF output signal. The resultant RF output pulse from the Signal Generator is of good quality at RF frequencies above 100 megacycles, is free of transients, and has low residual signal between pulses. On pulse operation the Signal Generator produces essentially no RF output signal until an external positive pulse is applied. When modulation signals are applied, neither the MODULATION control nor the PERCENT MODULATION meter can be used. However, any pulse above 10 volts amplitude will 100% modulate the output signal, and the peak level of the RF pulse will be within 1 db of the pulse-set level established by the settings of the RF OUTPUT control and the output attenuator. Figure 3-5 gives instructions for pulse modulation operation.

3-30. UNCALIBRATED RF OUTPUT.

3-31. The uncalibrated output (0.2 volt minimum) is an auxiliary signal for monitoring with a counter for extremely accurate measurements. It should not be used as an output comparable to the calibrated RF output.

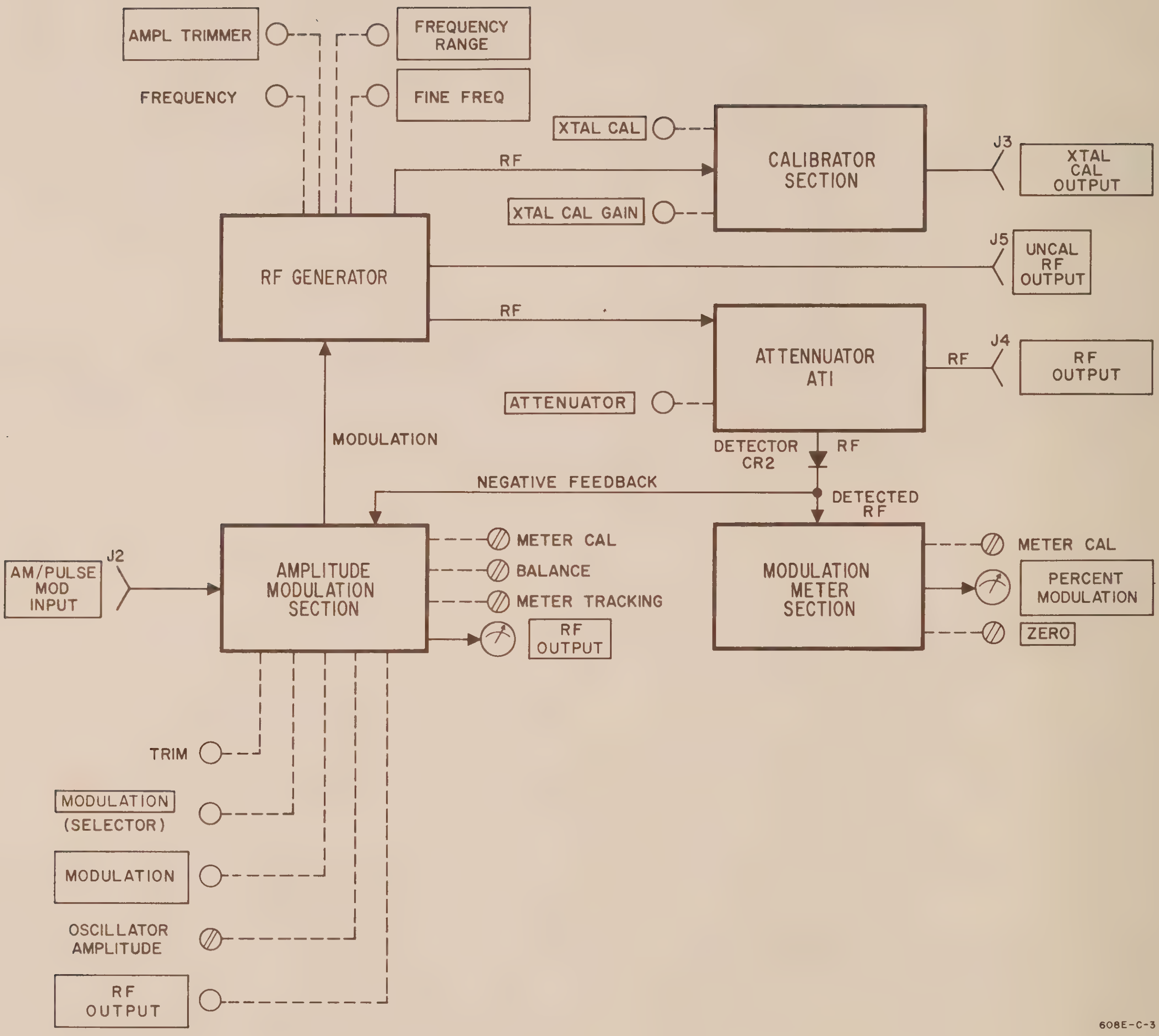


Figure 4-1. Overall Block Diagram

SECTION IV

PRINCIPLES OF OPERATION

4-1. INTRODUCTION.

4-2. This section contains explanations of the operation of the Signal Generator circuits. Figure 4-1 is a simplified block diagram showing principle circuit sections and operating controls. Each circuit section and important individual circuits are explained in succeeding paragraphs. As illustrated in Figure 4-1, the Signal Generator consists of an RF Generator, an Attenuator, an Amplitude Modulation Section, a Modulation Meter Section, and a Calibrator Section.

4-3. THE RF GENERATOR.

4-4. The RF Generator (Figure 4-2) includes RF Oscillator V6, Buffer Stage V22, and Power Amplifier V8. RF Oscillator V6 generates a sine-wave signal from 10 to 480 megacycles in five frequency bands. A type 4042 triode tube is used in a Colpitts circuit tuned by a split-stator capacitor and five separate RF transformers, L1 through L5. The tuning capacitor consists of two stator sections connected to the grid and plate of the oscillator tube and a floating rotor which meshes equally between the two stators. The

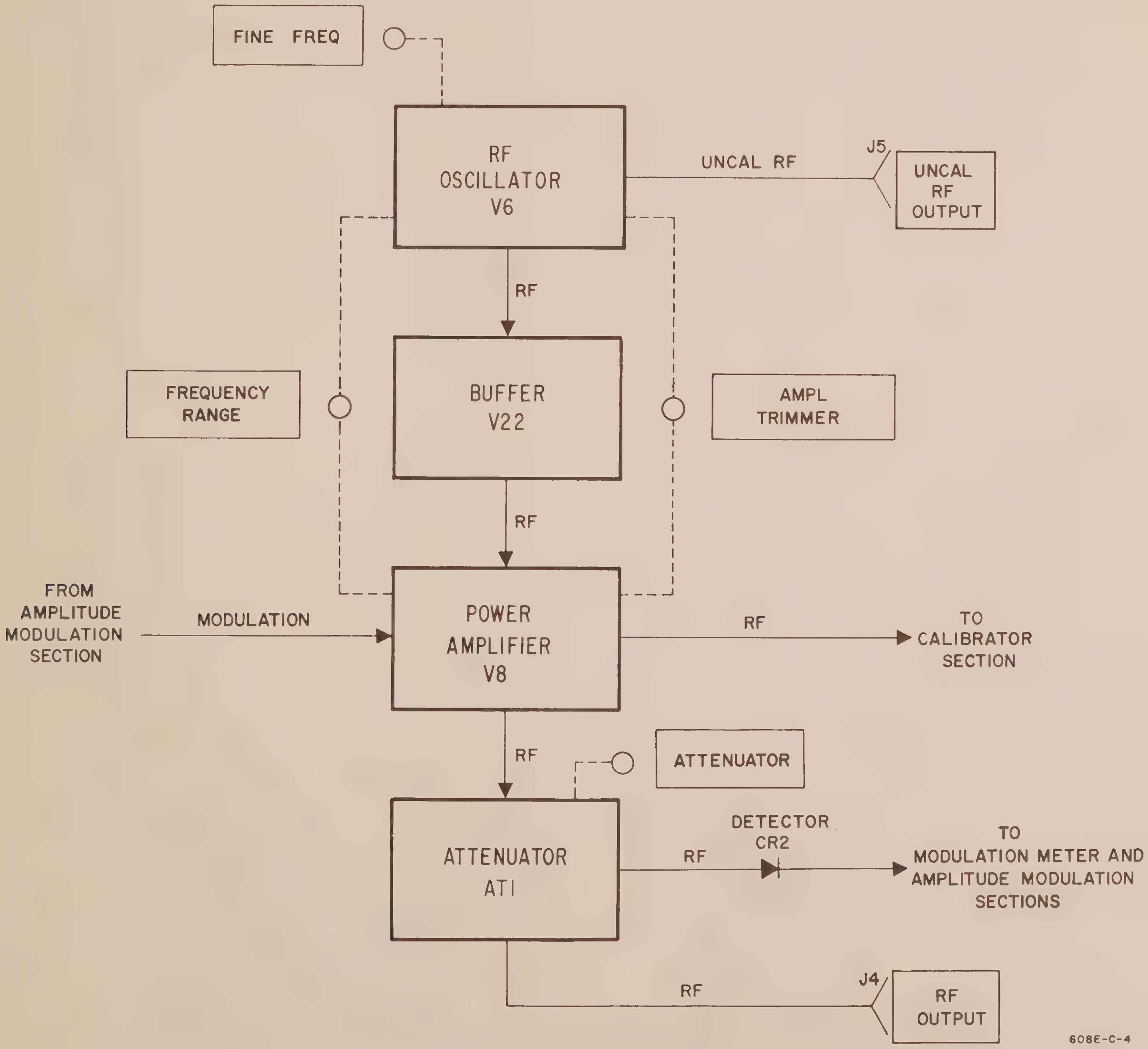


Figure 4-2. RF Generator

five inductors are mounted on a revolving turret actuated by the FREQUENCY RANGE selector.

4-5. RF Oscillator V6 is operated across the -165 volt and +225 volt supplies. The plate is series-fed through two 1500-ohm resistors, R246, R247, which reduce the plate voltage and also serve to isolate the tuned circuit from RF ground at Capacitor C15. The cathode is returned to -165 volts through resistors R249 and R43. Cathode bypass capacitor C25 is actually part of the tube mounting plate and is not visible when the mounting plate is in position. Resistor R249 prevents resonance in the cathode lead/Resistor R43, in conjunction with R246 and R247, limits the maximum plate current of V6. Bias for the control grid is obtained across grid-leak resistor R248, which develops approximately 70 volts of bias. Capacitor C16 couples the RF feedback from the tuning coil to the grid. The grid-plate capacity is shunted by the tuned circuit and a small trimmer capacitor C18, while the grid-cathode capacity is shunted by trimmer capacitor C59. Capacitor C18 sets the minimum capacity of the tuned circuit and is used to adjust the high-frequency limit of all bands when the oscillator tube is replaced. Capacitor C59' is an additional adjustment usually set for minimum capacity and requiring no adjustment. Capacitor C68, the FINE FREQ control, adds a small capacity to the existing capacity in the oscillator tank circuit.

4-6. Stable heater voltage for the oscillator tube is obtained from a regulated dc supply. All power to the oscillator tube is brought into the RF Generator housing through filters. These filters have high attenuation to radio frequencies to prevent radiation of the RF energy outside the instrument.

4-7. The secondary winding on each of the oscillator coils couples RF energy from the oscillator through a coaxial cable to the Buffer Stage. The Buffer tube is a type EC-8010 triode connected as an untuned grounded-grid amplifier and serves to isolate the Oscillator from the effects of the modulation signal at the cathode of the Power Amplifier. The Buffer reduces incidental frequency modulation to a small value.

4-8. Resistors R253 and R255 maintain a constant plate current for a wide range of tube characteristics and, in conjunction with resistors R254 and R256 (a dropping resistor in the plate supply lead), serves to limit plate current to safe values. Resistors R240, R242, R244 and R245, which are mounted on the coils for each band, damp undesirable resonance in the cathode. Resistors R241 and R243, shunting the A and B band coupling coils, limit the somewhat greater RF drive from these coils. The plate of the Buffer stage is coupled to the cathode of the Power Amplifier through a wide-band coupling network consisting of coil L20, dc blocking capacitor C244, and shunt peaking coils L22 and L11. Resistors shunting the peaking coils are used as the forms for the windings. The resistor values are selected to damp the resonant peaks of the coils.

4-9. Power Amplifier V8 amplifies the RF energy, received from the Buffer, for application to the RF output Attenuator. The circuit consists of a 4043 triode connected as a grounded-grid, cathode-modulated amplifier. The plate circuit of the Power Amplifier is tuned in the same manner as the Oscillator, with a similar split-stator capacitor and five untapped coils mounted on a revolving turret. The Power Amplifier tuning capacitor is ganged with the Oscillator capacitor. The Power Amplifier capacitor is provided with a mechanical linkage (adjusted by front-panel AMPL TRIMMER control), to shift the rotor plates from the normal tracking position with respect to the Oscillator. This control allows the Power Amplifier tuning to be separately adjusted for maximum output at all frequencies. The coil mounting turret is ganged with that of the Oscillator, and the coil in use is so located that the signal is inductively coupled to the output Attenuator probe.

4-10. THE ATTENUATOR.

4-11. To extract power (Figure 4-2) from the RF Power Amplifier a piston attenuator is used. The housing for the Attenuator projects through the rear of the RF generator housing and terminates, open-ended, close to the RF Power Amplifier plate-circuit inductor. A single-turn pickup loop at the end of the Attenuator probe couples energy to an impedance-matching network (C37, R59, C69, and R58) mounted on the face of the probe, and then through a section of double-shielded coaxial cable to the RF OUTPUT connector. Adjustable capacitor C37 is actually a movable slug in the probe body. It allows minor adjustment of the internal impedance of the generator so that the standing-wave ratio is minimum when the output connector is terminated in a 50-ohm resistive load. Capacitor C69 prevents possible pickup of spurious signals by eliminating a ground loop between the RF OUTPUT connector and Attenuator probe ground.

4-12. THE AMPLITUDE MODULATION SECTION.

4-13. The Amplitude Modulation Section (Figure 4-3) is comprised of a Wien-Bridge Oscillator (V2, a Differential Amplifier (Q2, Q3), Modulation Amplifiers (Q4 through Q7), Modulator (Q8, Q9), the RF OUTPUT meter, and appropriate switching circuits to select the mode of operation. The Amplitude Modulation Circuit has four operating modes: internal sine-wave modulation, external sine-wave modulation, external pulse modulation, and continuous-wave (CW) operation.

4-14. INTERNAL SINE-WAVE MODULATION.

4-15. This mode of operation is selected by placing the MODULATION selector to either 400~ or 1000~, causing the Wien-Bridge Oscillator to produce a 400±40 cps or 1000±100 cps output. The Wien-Bridge Oscillator consists of a two-stage resistance-coupled amplifier (V2A, V2B) which is caused to oscillate by frequency-selective positive feedback. At the resonant frequency there is no phase shift in the positive feedback thus voltage of the resonant frequency on the grid of the first tube is reinforced by the output of the second tube, and oscillation occurs.

4-16. A change in frequency is obtained by inserting different sets of resistors (R3, R5 or R4, R6) into the positive feedback network when the MODULATION

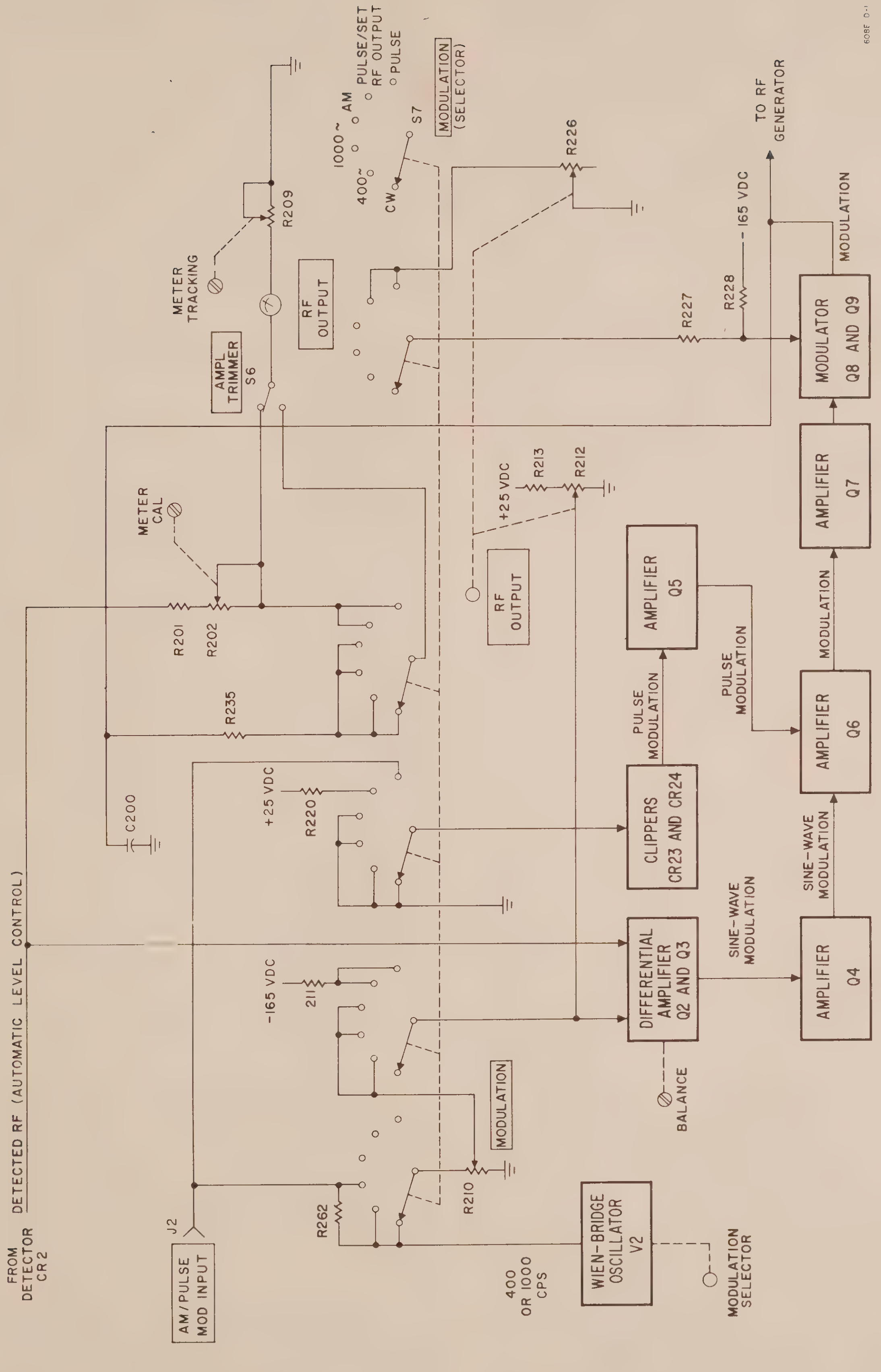


Figure 4-3. The Amplitude Modulation Section

selector is positioned from 1000 ~ to 400 ~. A negative feedback circuit is also used to stabilize the oscillator, reduce distortion, and to maintain a constant output level. This circuit consists of 10-watt lamp I1 (used as a thermal resistance), and resistors R7 and R8. The positive temperature coefficient of the lamp provides automatic amplitude control of the signal. If the amplitude of oscillation increases, current through the lamp increases, thereby increasing the lamp resistance; consequently, the negative feedback increases and amplitude of oscillation is maintained constant. Although heater voltage is applied to the oscillator at all times the 608E is in operation, plate voltage is applied to V2 only when the MODULATION selector is in the 400 ~ or 1000 ~ position.

4-17. The sine-wave signal from the modulation oscillator is coupled through dc blocking capacitor C205 and one section of the MODULATION selector switch to the MODULATION control, R210. In addition, the oscillator output is applied through resistor R262 to the AM/PULSE MOD INPUT connector for use as a synchronizing signal for external equipment. The sine wave is taken from the wiper of the MODULATION control and applied through frequency-compensation network R261, C203, C204, and another section of the MODULATION selector switch to one input of Differential Amplifier Q2, and Q3. The other input to the Differential Amplifier is the detected modulation signal from the cathode of Detector CR2. The differential amplifier produces an output proportional to the difference of the two inputs; hence, when the amplitude of the detected modulation signal increases, indicating an increase in RF power level, the output of the Differential Amplifier decreases to compensate, thus maintaining a constant RF output level.

4-18. Transistors Q2 and Q3 form a conventional Differential Amplifier. The collector of Q3 is decoupled for ac by R206 and C201. Potentiometer R204 serves to balance the conduction of the two transistors. A small amount of positive dc voltage is taken from the wiper of the RF OUTPUT control and applied through resistor R207 to the base of Q3 to establish the Amplifier operating point, and thus the nominal RF power level. One section of the MODULATION selector switch applies a fixed negative dc voltage (derived from the -165 volts through resistor R211) to the base of Q3 when set to the PULSE position; this voltage cuts off Q3 when in the external pulse mode. This same switch section connects capacitor C206 to the base circuit of Q3 when in the CW position; this capacitor decouples the base of Q3 for ac variations. The output of the Differential Amplifier (which is a function of the amplitude of the sine-wave output of the Wien-Bridge Oscillator, the feedback signal from the Modulation Meter Section, and the setting of the RF OUTPUT control) is amplified by Amplifiers Q4, Q6 and Q7.

4-19. The base circuit of Amplifier Q4 contains a frequency-compensation network composed of R214 and C202. Diode CR21 serves as a clipper to prevent the base voltage from going more negative than the emitter. Voltage divider R215 and R217, across the +25 volts, provides a small amount of reverse bias for Q4. The collector of Q4 is frequency-compensated by the network composed of C207, C208, R218, and R219. The output of Amplifier Q4 is developed across resistor R216 and applied to the base of Amplifier Q6.

4-20. Amplifier Q6 receives two inputs at its base; one input, from Q4, is present when operating in either the internal or external sine-wave modulation modes; the other input, from amplifier Q5, is present only when using external pulse operation (see paragraph 4-25). Resistors R223 and R224 form a voltage divider to provide a small amount of reverse bias for Q6. Resistor R22 serves as a load resistor. The signal at the collector of Q6 is applied to amplifier Q7.

4-21. Resistor R229 and capacitor C211, in the emitter of Q7, serve to provide emitter bias (emitter swamping) for Q7. The collector voltage for Q7 is applied through resistor R228, the load resistor. When the MODULATION selector switch is set to PULSE or PULSE/SET RF OUTPUT, a section of the switch causes resistors R228, R227, and potentiometer R226 (one-half of dual-section RF OUTPUT control) to form a voltage divider. Under these conditions, the RF OUTPUT control, when adjusted, simultaneously varies the collector voltage of Q7 and the base voltage of Modulator Q8, Q9, causing the dc level output of the modulator to alter the RF output of Power Amplifier V8.

4-22. The Modulator consists of two transistors, Q8 and Q9, in a parallel emitter-follower configuration. The collectors of Q8 and Q9 are decoupled by resistor R230 and capacitor C212. Resistors R31 and R32 serve as emitter swamping resistors to limit conduction of Q8 and Q9 to safe values. Clipper Diode CR25 prevents the bases of Q8 and Q9 from becoming negative with respect to their emitters. Breakdown Diode CR26, conducting through resistor R234, develops an additional 22 volts dc to boost the B-supply of Q8 and Q9 to a value sufficient to obtain adequate modulation of Power Amplifier V8. Resistor R233, in combination with R227, R228, and (when in pulse operation) R226 provide base biasing for Q8 and Q9. Capacitor C210 decouples the -165-volt line. The output of the Modulator is applied through filter FL6 to the cathode of Power Amplifier V8. In addition, the Modulator output is applied through filter R235, C200 and one section of the MODULATION selector switch to the RF OUTPUT meter, thereby causing an indication of RF power level.

4-23. EXTERNAL SINE-WAVE MODULATION.

4-24. Operation of the Modulator Section during this mode of operation is the same as when using internal sine-wave modulation except Wien-Bridge Oscillator V2 is disabled and the external sine-wave signal is applied from the AM/PULSE MOD INPUT connector to the MODULATION control, R210.

4-25. EXTERNAL PULSE MODULATION.

4-26. When using external pulse modulation, the Wien-Bridge Oscillator is again disabled and the modulating pulses are applied through one section of the MODULATION selector to the base of Amplifier Q5. Clippers

CR23 and CR24 serve to limit the pulse peak voltage to approximately ±0.5 volts. When in any sine-wave modulation mode or the CW mode, the MODULATION selector switch grounds the base of Q5, cutting-off the transistor. When the MODULATION selector is set to PULSE/SET RF OUTPUT, the +25 volts is applied through resistor R220, causing Q5 to continually conduct while the RF output is being calibrated. The output of Q5 is taken from the junction of resistors R221 (voltage-dropping resistor) and R216 (load resistor) and applied to the base of Amplifier Q6. From this point on, the operation of the Modulator Section is identical to that when using sine-wave modulation except the second section (R226) of the RF OUTPUT control is used to vary the RF output level by varying the base bias of Modulators Q8 and Q9. Note that the automatic RF leveling loop is not used during pulse modulation.

4-27. CW OPERATION.

4-28. During CW operation, all modulating input lines are opened by the MODULATION selector switch. The automatic RF leveling loop, however, operates normally.

4-29. RF OUTPUT METER CIRCUIT.

4-30. During CW and all sine-wave modulation modes and when in CW operation, a section of the MODULATION selector switch applies the filtered modulation output of Modulator Q8 and Q9 to the RF OUTPUT meter to provide an RF power-level indication. When using pulse operation or when adjusting the pulse power level, however, the MODULATION selector switch connects the RF OUTPUT meter (through resistors R201 and R202) to the base of Q2, where the automatic RF leveling feedback signal is present. In addition, the RF OUTPUT meter is also connected to the base of Q2 when the AMPL TRIMMER control is engaged and closes switch S6. It is necessary that the actual RF output be measured when using the AMP TRIMMER control or when adjusting pulse power level because the leveling feedback loop tends to cancel any change in RF output; thus, the change in RF output will not be reflected by a change in the voltage present at the junction of resistor R235 and capacitor C200. Potentiometers R202 and R209 serve as meter calibration and tracking adjustments, respectively.

4-31. THE MODULATION METER SECTION.

4-32. The Modulation Meter Section (Figure 4-4) consist of a Detector and Filter, a stabilized Wideband Amplifier, (V18, V19), and a Bridge-Type Metering Circuit (V20, V21). The PERCENT MODULATION meter is calibrated to indicate the modulation percentage of a given amount of RF carrier power. This amount is designated ATTENUATOR CALIBRATED (+7 db) on the RF OUTPUT meter.

4-33. Detector CR2 rectifies the RF signal taken from across resistor R60. The rectified RF signal is filtered by C38 and R119, leaving only the modulation frequency, and applied to Amplifier V18. This same signal is applied to the Amplitude Modulation Section to facilitate automatic leveling.

4-34. A Modulation Meter Amplifier consisting of amplifiers V18 and V19, is stabilized by negative feedback. The amplifier gives approximately 22 db of gain up to 2 Mc. The feedback path consists of R99 and C55. Output of the Modulation Meter Amplifier is applied to a Balanced Bridge Detector.

4-35. The circuit for the Bridge consists of rectifier V20 and twin-triode V21, the two triodes constituting two legs of the meter bridge. With no modulation signal applied, the steady-state dc potential at the plate of Amplifier V19 is coupled to the grids of both sections of V21. With equal current flowing in the two sides of the Bridge, the Bridge is balanced and the PERCENT MODULATION meter reads zero. Potentiometer R106 is a front panel zero adjustment of the bridge that provides for variations in tube and component values. When modulation signal is received from Amplifier V19, it is rectified by diode V20, and the peak value of the rectified voltage is applied to the triode in one leg of the Bridge, unbalancing the Bridge and causing the PERCENT MODULATION meter to read upscale. The triode in the other leg of the bridge is unaffected by the modulation signal as the signal is filtered by resistors R100, R101 and bypass capacitor C58. Potentiometer R104 is adjusted for correct calibration of the meter.

4-36. THE CALIBRATOR SECTION.

4-37. The Calibrator Section (Figure 4-5) consists of a 5-Mc Oscillator (V9A); a 1-Mc Oscillator (V9B), a Harmonic Generator and Mixer (CR1), an Amplifier (V10, V11), and output transformer T3. The 5-Mc Oscillator is a crystal-controlled electron-coupled Oscillator utilizing the pentode half of a type 6U8 tube.

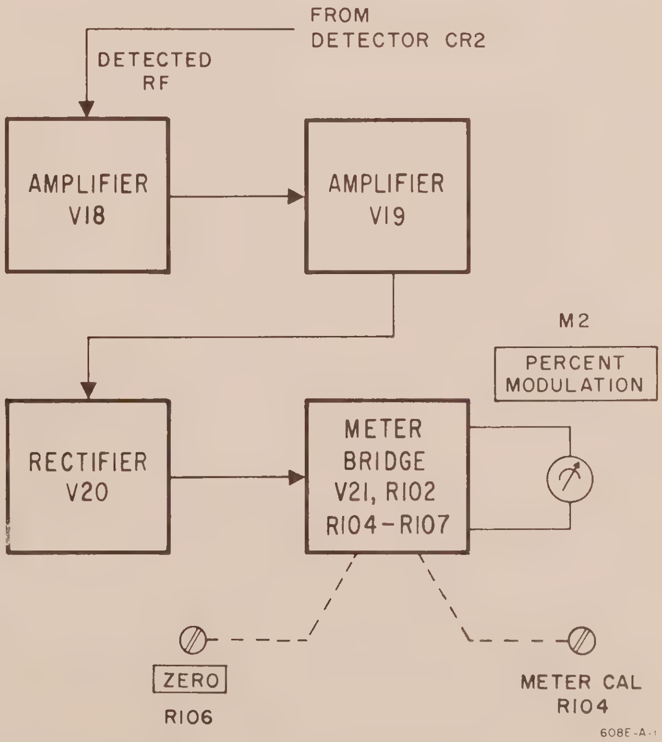


Figure 4-4. The Modulation Meter Section

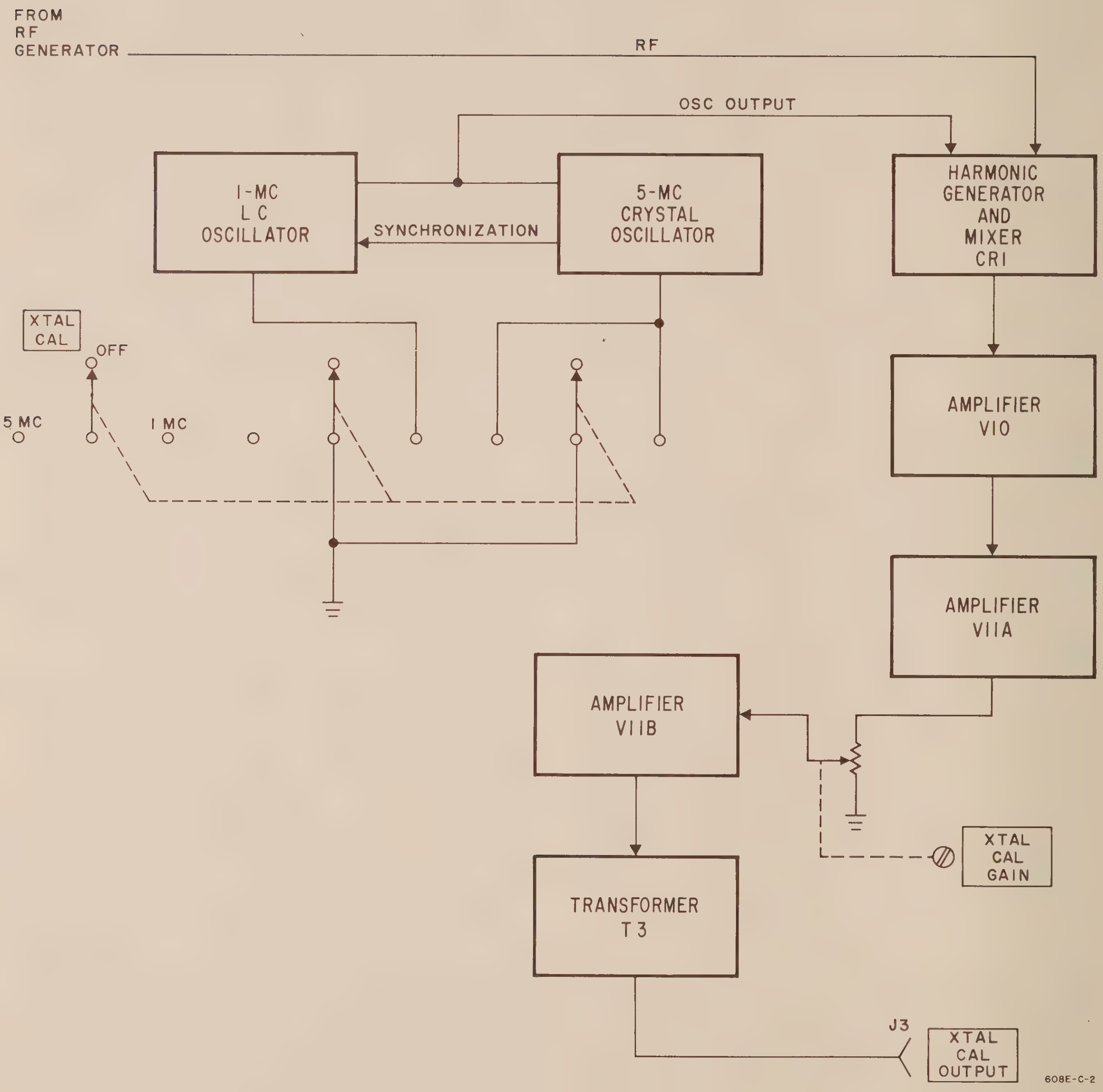


Figure 4-5. Calibrator Section Block Diagram

Both the plate and screen circuits are tuned to the crystal frequency of approximately 5 megacycles. Limited adjustment of the crystal frequency is provided by trimmer capacitor C23 connected across the crystal. The 1-Mc Oscillator (triode half of the 6U8) is adjusted so that its fifth harmonic synchronizes with the 5-Mc signal from the crystal-controlled Oscillator, ensuring a source of accurate 5-Mc and 1-Mc signals for calibration purposes.

4-38. The outputs of the Oscillators are coupled through blocking capacitor C24 to the cathode of Harmonic Generator and Mixer diode CR1. The signal from the RF Power Amplifier is inductively coupled to the anode of diode CR1 by running the anode lead of the diode close to the RF Amplifier circuits. Harmonics generated in the diode are mixed with the RF signal to produce audio beat-frequency signals across resistor R50.

4-39. The audio frequency signals from diode CR1 are applied through RF filter FL7 in the RF generator housing to a three-stage Amplifier consisting of V10 and V11. Only one half of V10 is used, the remaining half being grounded. Due to the extremely high gain (approximately 80 db) of the Amplifier, grounding of the input circuits is extremely critical. The load resistor (R50) for diode CR1 and the cathode-and-grid return resistor (R51) for V10 are not grounded near the tube socket, but are connected to the shield of the input cable. The cable is, in turn, grounded at the RF generator housing. Potentiometer R56 in the grid circuit of the last amplifier stage controls the volume of the audio beat-frequency output signal. The signal from the output stage is coupled through 600-ohm line-matching Transformer T3 to the front panel XTAL CAL OUTPUT jack.

4-40. THE POWER SUPPLIES.

4-41. GENERAL OPERATING PRINCIPLES.

4-42. All the dc operating voltages are electronically regulated. There are four electronic regulators, +225, -165, -6.3, and +25 volts. All the regulators operate as follows. As shown in Figure 4-6, a regulating element (Series Regulator) is connected in series with the load and the dc power source (Rectifier). The resistance of the regulating element is made adjustable so that the voltage at its output will be adjustable. The resistance is adjusted by a control voltage; the higher the control voltage, the higher the output voltage. A sample of the Series Regulator output voltage is compared against a stable dc reference voltage by a Comparison Amplifier and the difference voltage is inverted and applied to the Series Regulator. As a result, any tendency for the output voltage to change is immediately counteracted by the control voltage, and the output voltage remains constant.

4-43. The dc reference voltage used for comparison is obtained from voltage-regulator electron tubes, from semiconductor voltage-reference diodes, or by voltage division from a regulated power supply. When an adjustable power supply is used as the reference for another supply, changing its output level also changes the output level for the supply for which it is the reference. For example, the -165 volt supply has regulator tube V15 for reference, but its -165 volt output is the reference for the -6.3 and +225 volt supplies. Consequently, if this -165 volt reference varies, the output levels of both the -6.3 and +225 volt supplies change. Since the +225 volt supply is the reference for the +25 volt supply, the output of the +25 volt supply will be affected as well.

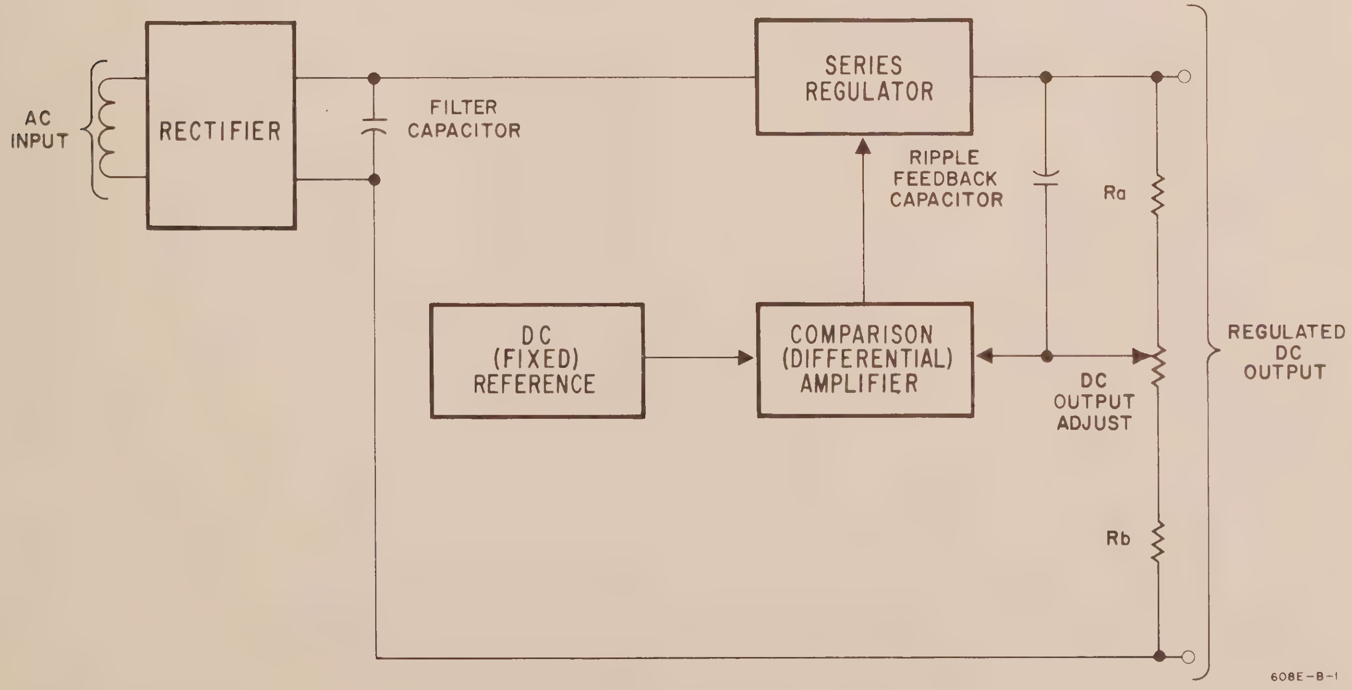


Figure 4-6. Power Supply Block Diagram

4-44. THE +225 VOLT SUPPLY.

4-45. The +225 volt supply operates as explained under General Operating Principles. The Comparison Amplifier, V12, reference voltage is applied to one end of voltage divider R70-R72 from the -165 volt supply. The screen voltage for the Comparison Amplifier is derived from voltage divider R65 and R66. The Series Regulator is comprised of V13A, V13B, and V16B. The +225 volt supply is the voltage source for the +25 volt supply reference.

4-46. THE -165 VOLT SUPPLY.

4-47. The -165 volt supply operates as explained under General Operating Principles. The Comparison Amplifier, V14, reference voltage is developed by Reference Tube V15. Screen-grid voltage for the Comparison Amplifier is derived from voltage divider R74, R115. The Series Regulator is comprised of V16A. This supply is independent and does not rely on other supplies for reference or tube supply voltages.

4-48. THE +25 VOLT SUPPLY.

The +25-volt supply operates as explained under General Operating Principles. The Comparison Amplifier, Q10, reference voltage is obtained from breakdown Diode CR28. The Series Regulator is comprised of transistor Q11. The collector voltage for the Comparison Amplifier is obtained from the +225-volt supply. Any failure or extreme change in the +225-volt output will, consequently, affect the +25-volt output.

4-50. THE -6.3 VOLT SUPPLY.

4-51. The -6.3 volt supply operates as explained under General Operating Principles except the Comparison Amplifier and Series Regulator are combined into one transistor stage, Q1. The reference voltage is provided by breakdown diode CR20 in combination with the -165 volt supply. Any failure or extreme change in the -165 volt output thus affects the -6.3 volt output.

SECTION V
MAINTENANCE

5-1. INTRODUCTION.

5-2. This section provides instructions for performance testing, calibrating, troubleshooting, and repairing the Signal Generator.

5-3. PERIODIC INSPECTION.

5-4. CLEANING.

5-5. If the equipment has been subjected to unusual conditions (excessive moisture, dust, heat, vibration, etc.) it is suggested that the instrument be removed from the cabinet and inspected for dirt or moisture accumulation, loosened components, or any possible sign of damage. Forced air under medium pressure is recommended for dusting and drying, although care must be taken not to vary the settings of the internal-adjustment potentiometers and capacitors during the process.

5-6. LUBRICATION.

5-7. The 608E is thoroughly lubricated at the factory. Fully shielded ball bearings are used in many applications and require no subsequent attention. Ball bearings that are not fully shielded require only light machine oil. After prolonged use of the instrument, lubricated points should be checked for excessive dust accumulation or drying of lubricant.

5-8. The two worm gears used in the tuning-capacitor drive should be cleaned and lubricated approximately every sixty days. This maintenance is particularly important when the instrument is operated continuously or for several hours daily. Calibration accuracy and instrument dependability can be maintained only by proper lubrication of the two worm gears in the tuning mechanism. Other rubbing surfaces and sleeve bearings, including the small pulleys used in the attenuator drive system, should be lubricated quarterly with a light slideway oil such as Shell Tonna G. In all cases avoid overlubrication. The points to be lubricated are listed in Table 5-1.

5-9. PERFORMANCE TESTS.

5-10. PURPOSE.

5-11. The following paragraphs check performance for incoming inspection, periodic evaluation, troubleshooting and calibration. The tests can be performed without access to the Signal Generator interior. The specifications of Table 1-1 are the performance standards.

5-12. TEST EQUIPMENT REQUIRED.

5-13. The test instruments required to make the performance tests are listed in Table 5-2. Test instruments other than those listed may be used provided performance equals or exceeds critical specifications. Two test instruments must be fabricated: a 100-ohm termination and a loop antenna. See Figure 5-2 for fabrication of these items.

5-14. FREQUENCY ACCURACY AND RESETTABILITY CHECK.

a. Connect Signal Generator in test setup shown in Figure 5-3.

b. Set MODULATION switch to CW.

c. Align cursor knob with alignment mark.

d. Align FINE FREQ pointer with alignment mark.

e. Set FREQUENCY RANGE to band A.

f. Adjust RF OUTPUT and attenuator controls to obtain proper triggering of Electronic Counter.

g. Sequentially adjust frequency control to the low end, approximate center, and high end of band A; record dial and Electronic Counter indications. Electronic Counter should indicate within ±0.5% of MEGACYCLES dial indication at each setting of frequency control.

Table 5-1. Lubrication Chart

Lubrication Point (See Figure 5-1)	Lubricant
Oscillator and amplifier worm gears	"Molykote (type Z)"
AMPL TRIMMER stop mechanism	Light machine oil
AMPL TRIMMER toggle nut	Light machine oil
AMPL TRIMMER drive link	Light machine oil
Amplifier worm drive shaft	Light machine oil
RF Amplifier sliding coupler	Light machine oil
Attenuator pulleys	Light machine oil
Attenuator drive shaft bearing (front)	Light machine oil
Attenuator drive shaft bearing (rear)	Light machine oil

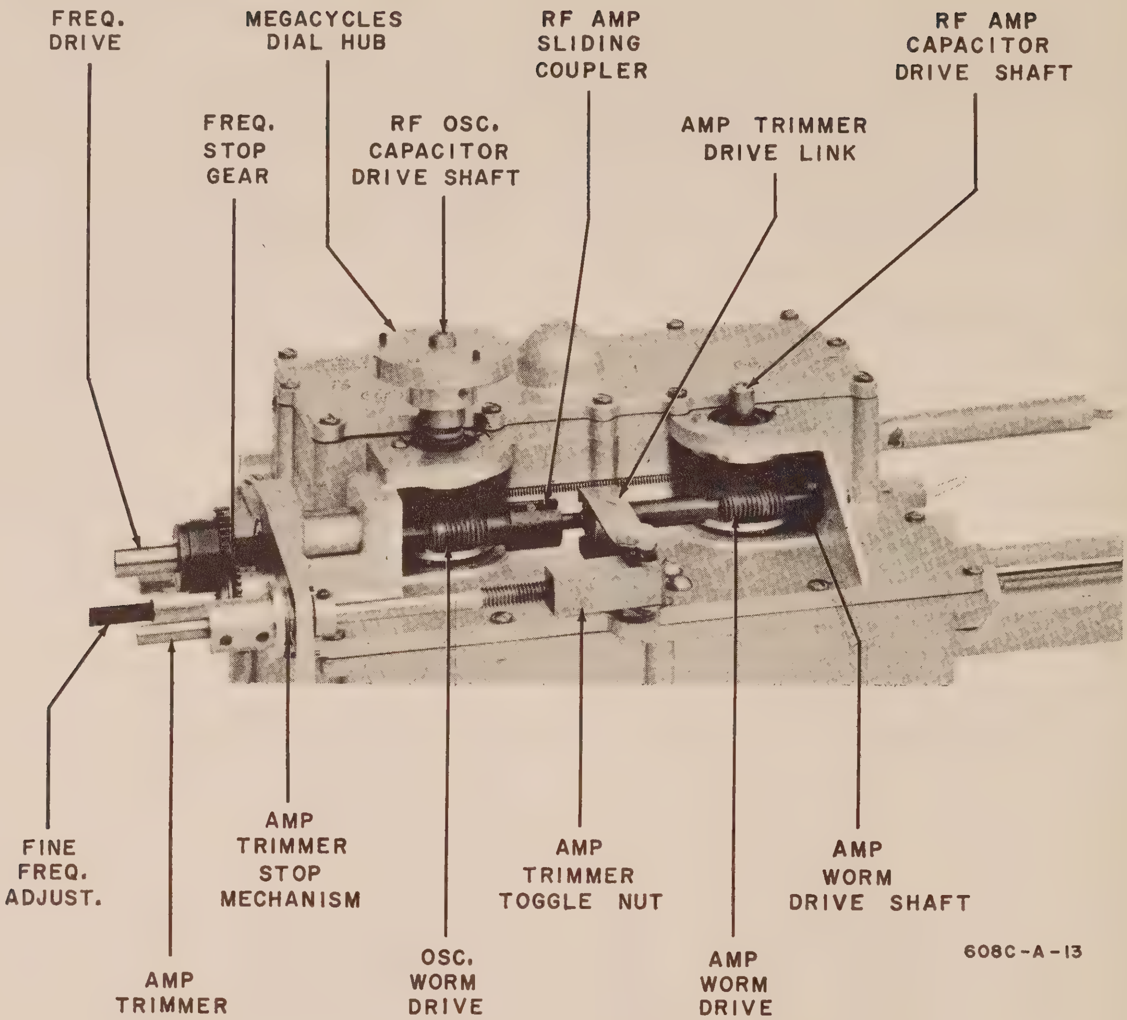


Figure 5-1. RF Tuner Drive Mechanism

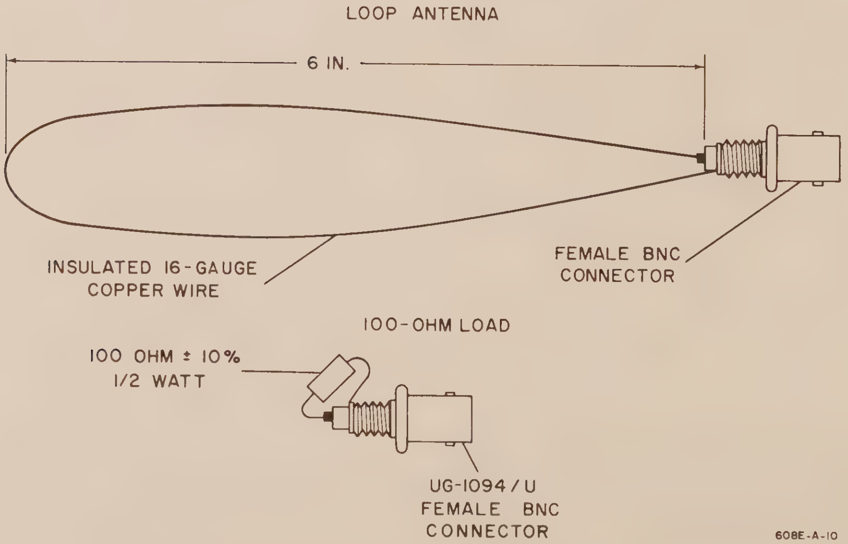


Figure 5-2. Fabrication of Test Equipment

Table 5-2. Test Equipment Required for Performance Testing, Adjustment, and Troubleshooting

Instrument	Critical Specifications	Recommended Model
Electronic Counter	Frequency Range: 10 Mc to 480 Mc Accuracy: ±0.005%	hp 5245L with 5253B plug-in unit
Power Meter	Range: 10 microwatts to 10 milliwatts Accuracy: ±5% of full scale	hp 431B
Thermistor Mount	Frequency Range: 10 to 480 Mc SWR: 1.6 max	hp 478A
Coaxial Attenuator	Attenuation: 10 db	hp 8491A
Coaxial Attenuator	Attenuation: 20 db	hp 8492A
Oscillator	Frequency Range: 20 cps to 20 kc Envelope Distortion: 0.5% max Output: 1 volt rms	hp 200CD
VTVM	Voltage Range: 0.1 millivolt to 300 volts Decibel Range: -72 to +52 db Frequency Range: 20 cps to 6 Mc	hp 400E
Sampling Oscilloscope	Sampling Rate: 100 kc Vertical Output: -1 volt at bottom of CRT face to +1 volt at top	hp 185B with 187 plug-in unit
Low-Pass Filter	Cutoff Frequency: 50 kc	Allison 2D
Distortion Analyzer	Range: 20 cps to 20 kc Accuracy: ±3%	hp 330B
Deviation Meter	Frequency Range: 50 to 150 Mc Accuracy: ±3% Deviation Range: 0 to 5 Kc	Measurements Corp. Model 140
Oscilloscope	Vertical Bandwidth: 5 Mc Vertical Sensitivity: 5 mv/cm	hp 140A with 1402A plug-in unit
Adapter	None	UG-201A/U
Crystal Detector	Frequency Range: 40 to 220 Mc VSWR: 1.2 max Deviation from Square Law: less than 0.5 db over a range of at least 30 db	hp 423A, Option 02
Dummy Load	Resistance: 100 ohms ±10% Wattage: 1/2 watt	See Figure 5-2
Pulse Generator	Pulse Width: 10 μsec Pulse Amplitude: 10 volts peak into 2K ohms. Pulse Rise and Decay: 0.02 μsec max Repetition Rate: 50 to 5000 pps	hp 212A
Loop Antenna	Special	See Figure 5-2
Receiver	Frequency: 400 Mc Sensitivity: 1 microvolt for rated IF output IF output: 1 millivolt minimum	Eddystone Model 770U
DC Ammeter	Range: 15 to 30 milliamperes Accuracy: ±5%	hp 428
SWR Meter	Sensitivity: at least 1 microvolt full scale Attenuator Range: 40 db Attenuator Accuracy: ±0.1 db	hp 415E

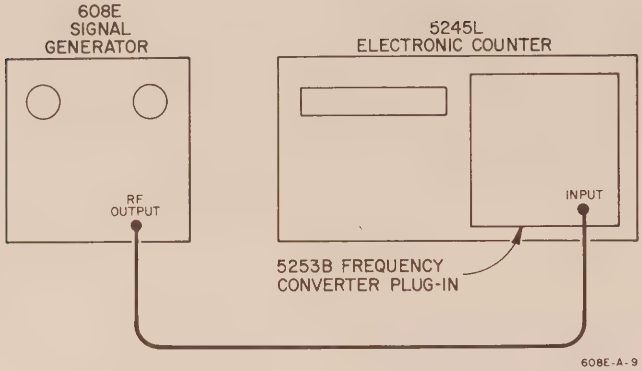


Figure 5-3. Frequency Accuracy and Resettability Test Setup

h. Reset frequency control to each dial reading recorded in step g. Electronic Counter should indicate within ±0.1% of appropriate Counter indication recorded in step g.

i. Repeat steps g and h for each band setting of FREQUENCY RANGE switch.

5-15. CALIBRATOR ACCURACY CHECK.

a. Connect Signal Generator in Test Setup shown in Figure 5-3.

b. Plug headset into XTAL CAL OUTPUT connector.

c. Set XTAL CAL switch to 5 Mc.

d. Set FREQUENCY RANGE to band E.

e. Align cursor knob and FINE FREQ controls with panel markers.

f. Adjust frequency control to approximately 480 Mc.

g. Adjust RF OUTPUT and attenuator controls for proper triggering of Electronic Counter.

h. Adjust frequency control for zero beat signal in headset. Adjust XTAL CAL GAIN as required.

i. Electronic Counter indication should be within ±0.01% (±48 Kc) of 480 Mc.

j. Set XTAL CAL switch to 1 Mc.

k. Repeat steps h and i.

5-16. FREQUENCY-DRIFT CHECK.

a. Connect Signal Generator in Test Setup shown in Figure 5-3.

b. Set MODULATION switch to CW.

c. Set FREQUENCY RANGE switch to band A.

d. Adjust frequency control for 15 Mc.

e. Adjust RF OUTPUT and attenuator controls to obtain proper triggering of Electronic Counter, and allow 10 minutes for Signal Generator to stabilize.

f. Record Electronic Counter indication.

g. Wait 10 minutes and again record Electronic Counter indication. Frequency should be within ±0.005% (±750 cps) of that recorded in step f.

h. Repeat steps f and g for the following FREQUENCY RANGE and frequency control settings. Allow 10-minute stabilization period at each new frequency.

Frequency Range	Frequency	Max. Drift
Band B	30 Mc	±1.50 kc
Band C	75 Mc	±3.750 kc
Band D	150 Mc	±7.50 kc
Band E	340 Mc	±17.0 kc

5-17. RESIDUAL FM CHECK.

5-18. Figure 5-4 shows a generalized test setup to perform the residual FM check. The check is per-

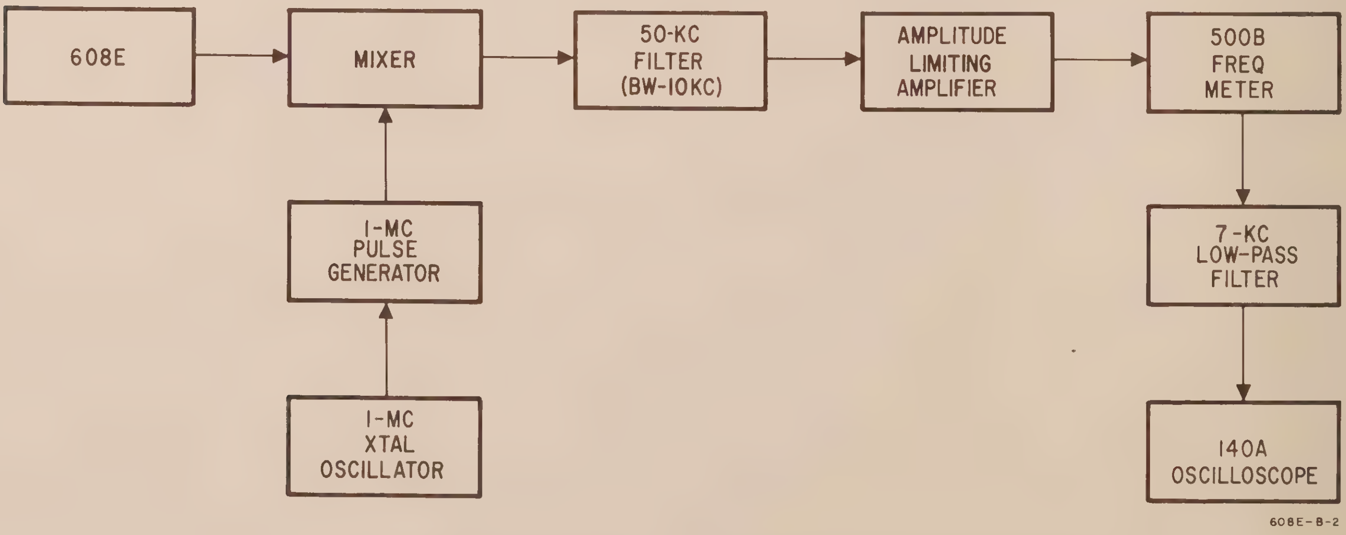


Figure 5-4. Suggested Residual FM Test Setup

formed with the Model 608E generating a CW signal with an output level of +7 db (attenuator at 0 db). The Model 608E output frequency is initially adjusted to approximately 10 Mc and then adjusted for a maximum 50-kc indication on the Model 500B Frequency Meter. The peak-to-peak voltage indication is observed on the Oscilloscope to determine the residual FM. The residual FM should be checked at Signal Generator frequencies of 10, 30, 70, 150, 300, 400, 420, 450, and 480 Mc, peaking the Frequency Meter indication at each frequency. Maximum residual FM should be less than 5 parts in 10^{-7}.

5-19. MAXIMUM RF OUTPUT CHECK.

a. Connect Signal Generator in Test Setup shown in Figure 5-5.

b. Adjust Signal Generator controls as follows:

FREQUENCY RANGE	band A
RF OUTPUT control	max. cw
MODULATION selector	CW
Attenuator	+7 dbm

c. Rotate frequency control through entire range while depressing and adjusting AMPL TRIMMER for maximum RF output. (If necessary, temporarily adjust RF OUTPUT control to obtain useable RF OUTPUT meter reading.) Power Meter should indicate minimum of +3 dbm over entire band.

d. Repeat step d for the remaining four positions of the FREQUENCY RANGE switch.

5-20. FREQUENCY RESPONSE AND LEVELING CHECK.

a. Connect Signal Generator in Test Setup shown in Figure 5-5.

b. Set MODULATION selector to CW, and attenuator control to +7 dbm.

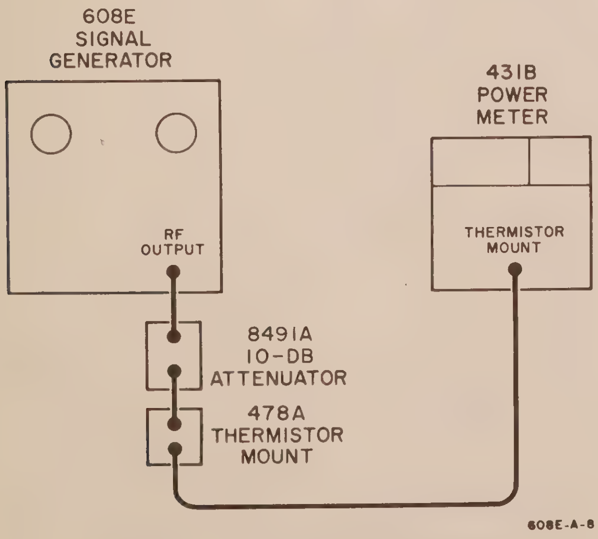


Figure 5-5. RF Output Test Setup

c. Set FREQUENCY RANGE switch to band D and adjust frequency control to lower end of band.

d. Depress and adjust AMPL TRIMMER for maximum RF output.

e. Adjust RF OUTPUT for +7 dbm on RF OUTPUT meter.

f. Vary frequency control over entire frequency range of band D. Peak-to-peak Power Meter variation should be less than 2 db over entire frequency range.

g. Repeat steps c through f for bands C, B, and A.

h. Set FREQUENCY RANGE switch to band E and adjust frequency control to lower end of band.

i. Depress and adjust AMPL TRIMMER for maximum RF output.

j. Vary frequency control over lower half of band E. Power Meter variation should be less than 2 db over lower half of band.

k. Adjust frequency control to center of band E, and depress and adjust AMPL TRIMMER for maximum RF output.

l. Adjust RF OUTPUT control for +7 dbm on RF OUTPUT meter.

m. Vary frequency control over upper half of band E. Peak-to-peak Power Meter variation should be less than 2 db over upper half of band.

5-21. RF OUTPUT ACCURACY CHECK.

a. Connect Signal Generator in Test Setup shown in Figure 5-5, but omit 10-db attenuator.

b. Set MODULATION switch to CW.

c. Set FREQUENCY RANGE switch to band C and adjust frequency control to 70 Mc.

d. Depress and adjust AMPL TRIMMER for maximum RF output.

e. Adjust RF OUTPUT control for +7 dbm on RF OUTPUT meter.

f. Set attenuator control to 0 dbm. Power Meter should indicate 0±1 db.

g. Without changing any Signal Generator control settings, connect Signal Generator in test setup shown in Figure 5-6.

h. Set MODULATION selector to 1000~, and adjust Signal Generator MODULATION control for 100% modulation.

i. Adjust Model 415E for a convenient reference level.

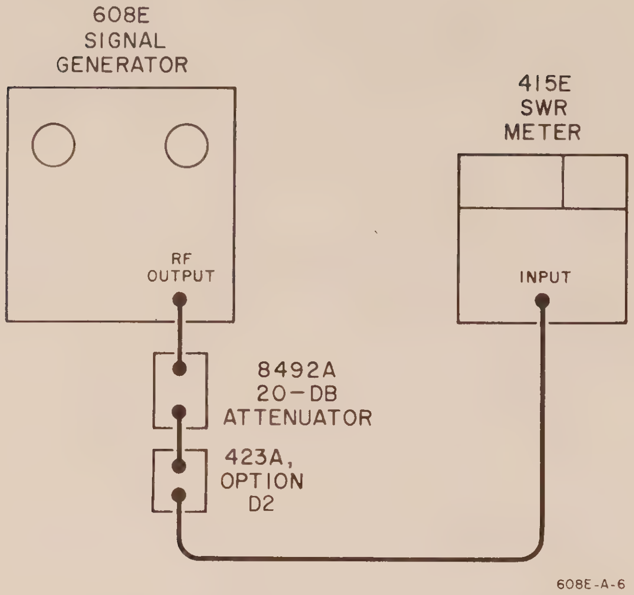


Figure 5-6. RF Output Accuracy Test Setup

j. Adjust Signal Generator attenuator control from +7 dbm to lower limit of Model 415E sensitivity, comparing attenuator setting and Model 415E indication. Maximum deviation from linearity should be 1 db.

k. Remove Model 8492A attenuator from test setup. Continue adjustment of Signal Generator attenuator control to lower limit of Model 415E. Maximum deviation from linearity should be 1 db.

5-22. UNCALIBRATED RF OUTPUT CHECK.

a. Connect Signal Generator in test setup shown in Figure 5-7.

b. Power Meter should indicate -0.95 dbm minimum.

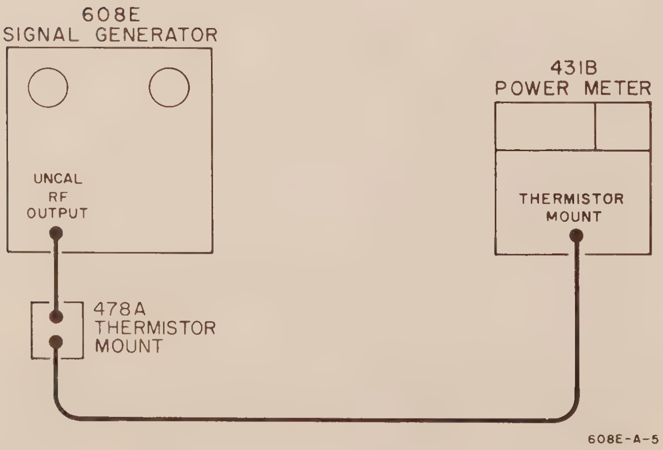


Figure 5-7. Uncalibrated RF Output Test Setup

5-23. EXTERNAL SINE-WAVE MODULATION AND MODULATION METER CHECK.

a. Connect Signal Generator in test setup shown in Figure 5-8.

b. Set MODULATION selector to AM.

c. Adjust Model 200CD for a 2-Kc, 1-volt rms output.

d. Adjust MODULATION control to maximum clockwise position. PERCENT MODULATION meter should indicate at least 90% modulation.

e. Adjust MODULATION control for 90% modulation on PERCENT MODULATION meter.

f. Adjust Oscilloscope to view modulation envelope, and adjust oscilloscope gain for envelope amplitude of 10 cm peak-to-peak.

g. Measure peak-to-peak amplitude (in centimeters) of modulation envelope from uppermost peak to uppermost trough. Peak-to-peak amplitude should be 4.5 ±0.5 cm (90 ±10% modulation).

h. Repeat steps e, f, and g for the following modulation percentages:

Percent Modulation Meter (%)	Amplitude (cm)	Equivalent Modulation Percentage (%)
80	4.0 ± 0.25	80 ± 5
70	3.5 ± 0.25	70 ± 5
60	3.0 ± 0.25	60 ± 5
50	2.5 ± 0.25	50 ± 5
40	2.0 ± 0.25	40 ± 5
30	1.5 ± 0.25	30 ± 5
20	1.0 ± 0.25	20 ± 5
10	0.5 ± 0.25	10 ± 5

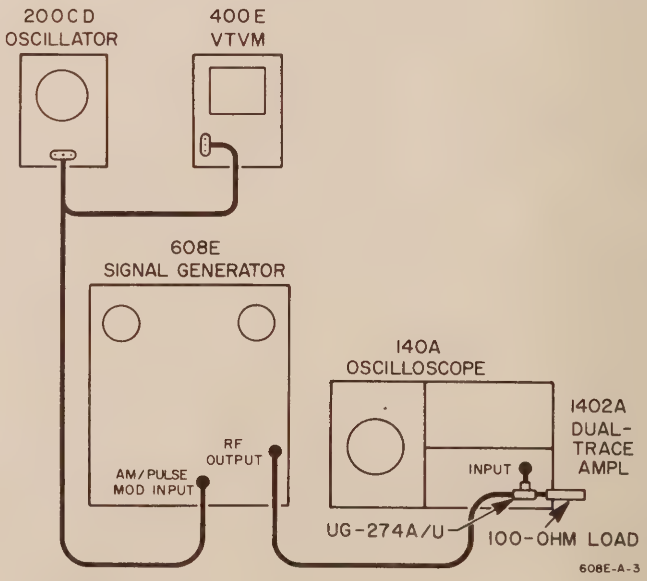


Figure 5-8. External Sine-Wave Modulation and Modulation-Meter Test Setup

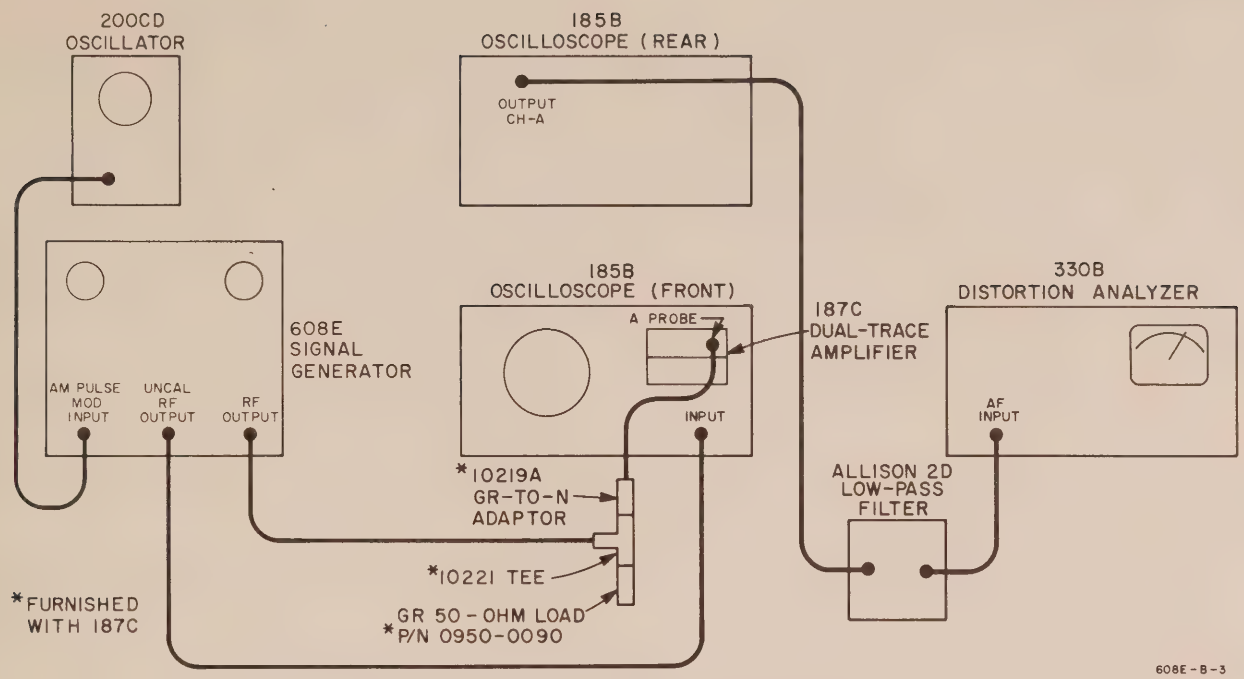


Figure 5-9. Envelope Distortion Test Setup

5-24. INTERNAL MODULATION CHECK.

a. Set MODULATION selector to 1000~.

b. Adjust MODULATION control to maximum clockwise position. PERCENT MODULATION meter should indicate at least 90% modulation.

c. Adjust MODULATION control to maximum counterclockwise position. PERCENT MODULATION meter should indicate 0% modulation.

d. Set MODULATION selector to 400~.

e. Repeat steps b and c.

5-25. ENVELOPE DISTORTION CHECK.

a. Connect Signal Generator in test setup shown in Figure 5-9.

b. Set FREQUENCY RANGE switch to band A, and frequency control to low end of band.

c. Set MODULATION selector to CW.

d. Adjust RF OUTPUT and attenuator for suitable input signal to Oscilloscope.

e. Adjust Oscilloscope for automatic (100 Kc) sampling rate.

f. Adjust Model 185A for manual scanning.

g. Adjust Model 185A scan for maximum vertical deflection (sampling at peak of RF waveform).

h. Set MODULATION selector to AM.

i. Adjust Model 200CD for a 20-cps, 1-volt rms output.

j. Adjust MODULATION control for 30% modulation.

k. Measure distortion with Model 330B. Distortion should be 1% or less.

l. Adjust Model 200CD for a 15-Kc, 1-volt rms output.

m. Adjust MODULATION control for 30% modulation.

n. Repeat step k.

o. Adjust frequency control to high end of band.

p. Repeat steps i through n.

q. Repeat steps b through p for each of the remaining band settings of FREQUENCY RANGE switch.

5-26. INCIDENTAL FM CHECK.

Note

The following procedure provides an indication of incidental FM. Because the measurement is made at the low end of the Deviation Meter, there exists a broad range of ambiguity. For a more precise measurement, use the procedure outlined in paragraph 5-17.

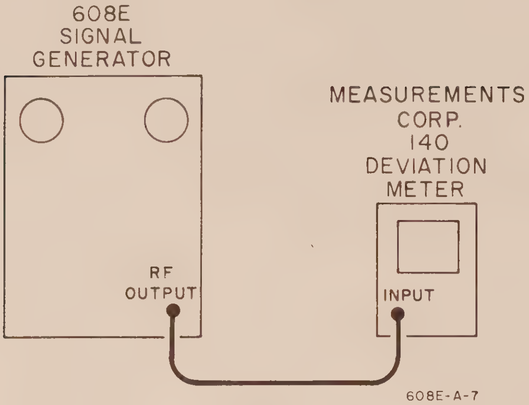


Figure 5-10. Incidental FM Test Setup

a. Connect Signal Generator in test setup shown in Figure 5-10.

b. Set MODULATION selector to 1000~.

c. Adjust RF OUTPUT and attenuator for proper level at Standard Deviation Meter.

d. Adjust Signal Generator for an output frequency of 150 Mc.

e. Adjust MODULATION control for 50% modulation.

f. Standard Deviation Meter should indicate less than 1-kc deviation.

g. Adjust Signal Generator for an output frequency of 50 Mc.

h. Standard Deviation Meter should indicate less than 0.5-kc deviation.

5-27. EXTERNAL PULSE-MODULATION AND RESIDUAL-LEVEL CHECK.

a. Connect Signal Generator in test setup shown in Figure 5-11.

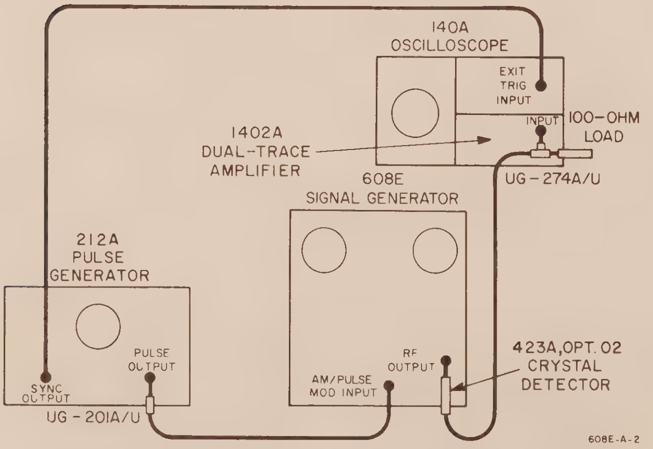


Figure 5-11. Pulse Modulation Test Setup

b. Adjust Model 212A Function Generator for a pulse output of 10 volts peak-to-peak, 10 μsec wide.

c. Adjust frequency control 40 Mc.

d. Adjust Signal Generator controls as follows:

MODULATION selector	PULSE/SET RF OUTPUT
AMPL TRIMMER	max. RF output
RF OUTPUT control	+7 dbm on RF OUTPUT meter
Attenuator	+7 dbm

e. Set MODULATION selector to PULSE; check Oscilloscope for following pulse-modulation characteristics:

Combined pulse rise and decay time	4 μsec max.
Pulse width	10 ±1.5 μsec
Pulse overshoot	15% max.

f. Adjust frequency control to 220 Mc.

g. Repeat step d.

h. Set MODULATION selector to PULSE; check Oscilloscope for following pulse-modulation characteristics:

Combined pulse rise and decay times	2 μsec max.
Pulse width	10 ±1.5 μsec
Pulse overshoot	15% max.

i. Connect Signal Generator in test setup shown in Figure 5-5 but delete 10-db attenuator.

j. Repeat step d.

k. Set MODULATION selector to PULSE and measure RF output on Power Meter; RF output should be -13 db minimum.

5-28. RF LEAKAGE CHECK.

a. Connect Signal Generator in test setup shown in Figure 5-12.

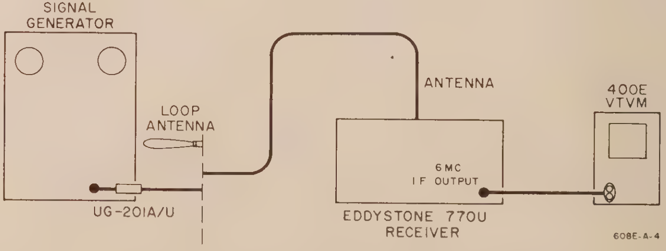


Figure 5-12. RF Leakage Test Setup

b. Set Signal Generator Controls as follows:

MODULATION selector	CW
RF OUTPUT	+7 dbm on RF OUTPUT meter
Attenuator	1 μV
FREQUENCY RANGE	band E
AMPL TRIMMER	max. RF output

c. Connect Model 7700 Receiver antenna to Model 608E RF OUTPUT connector, and adjust receiver to 400 Mc.

d. Set Model 608E frequency control to approximately 400 Mc, then adjust frequency control for maximum indication on Model 400E Voltmeter.

e. Adjust Model 400E to -40-db range.

f. Adjust Model 7700 IF gain for 0-db indication on Model 400D. (This corresponds to 1 microvolt output from Model 608E.)

g. Disconnect Model 7700 antenna from RF OUTPUT connector.

h. Connect Model 7700 input to loop antenna (see Figure 5-2).

i. Probe over entire cabinet area with loop antenna and observe Model 400D. Model 400D indication should not exceed 0 db.

5-29. ADJUSTMENT.

5-30. TEST EQUIPMENT REQUIRED.

5-31. Test instruments required to perform the adjustments and calibrations are listed in Table 5-2.

Instruments other than those listed may be substituted, provided their specifications equal or exceed the critical specifications. Two test instruments must be fabricated; a 100-ohm termination and a loop antenna. See Figure 5-2 for fabrication of these items.

5-32. POWER SUPPLY VOLTAGE ADJUSTMENTS.

5-33. There are four adjustable dc operating voltages: -165, +225, +25, and -6.3 volts. Adjust these voltages only if proven by accurate measurement to be outside the tolerances specified below and only if the voltage error is not caused either by excessive current being drawn through the regulator or by inadequate voltage being supplied to the regulator from the power supply rectifiers.

5-34. Because of the interdependence of these power supplies, the -165 volt regulator must be set first, the +225 volt regulator second, and the +25 and -6.3 volt regulators last. After adjusting any of these regulators, check the output voltage of each other regulator to be sure it is still within specified tolerances.

a. Connect an adjustable transformer to control line voltage applied to Signal Generator.

b. Set Signal Generator controls as follows:

MODULATION control	max. ccw
RF OUTPUT	max. cw
FINE FREQ	centered
Frequency	high end stop
AMPL TRIMMER	max. cw
MODULATION selector	CW
Attenuator	max. cw
Power switch	ON
XTAL CAL	OFF

c. Adjust line voltage transformer to deliver 115 (or 230) volts. Be sure 115/230 volt switch is set correctly.

d. Measure and, if necessary, adjust the following voltages:

Voltage	Adjustment (Figure 5-13)
-165 ±5	R80
+225 ±5	R71
+25 ±1	Replace CR28 if necessary
-7.2 ±0.3	Replace CR20 if necessary

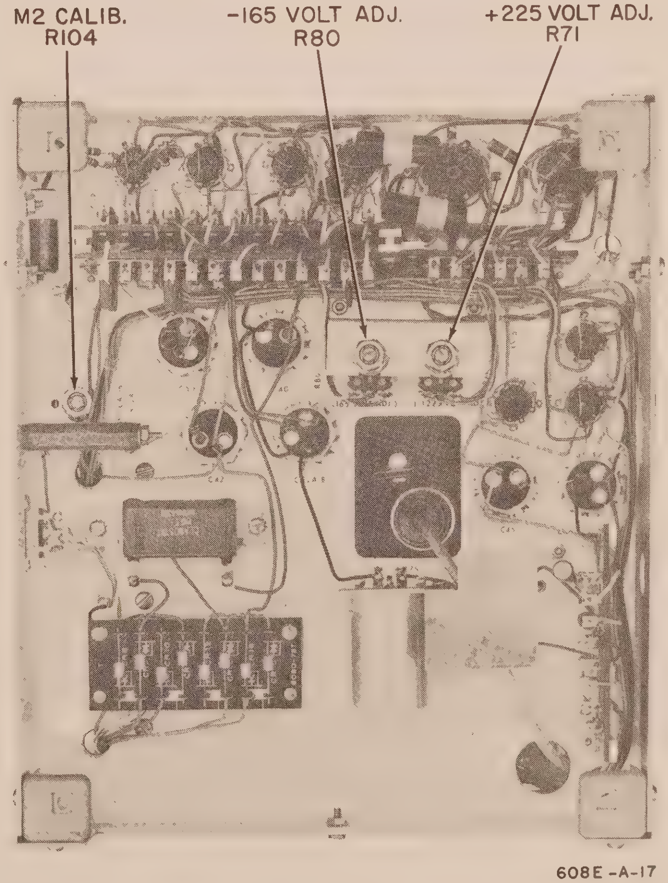


Figure 5-13. Location of Power Supply and Modulation Meter Adjustments

5-35. MODULATION METER ADJUSTMENT.

5-36. MECHANICAL ZERO. Adjust mechanical zero as follows:

a. Set MODULATION selector to CW.

b. Connect shorting lead across PERCENT MODULATION meter terminal.

c. Adjust mechanical zero-adjust screw clockwise until pointer is at left of meter zero and moving towards meter zero; stop adjustment when meter needle is exactly at zero. If needle overshoots, repeat adjustment.

d. Carefully adjust mechanical zero-adjust screw a few degrees to free screw from meter suspension. If pointer moves off zero, repeat step c.

e. Remove shorting lead from meter terminals.

5-37. ELECTRICAL ZERO. Adjust electrical zero as follows:

a. Adjust R106 (front-panel ZERO adjustment) fully clockwise. PERCENT MODULATION meter should indicate at least 30% modulation.

b. Adjust line voltage from 102 to 128 (or 204 to 256) volts. PERCENT MODULATION meter indication should not change more than ±10% of full scale.

c. Adjust line voltage to 115 (or 230) volts. Adjust R106 for zero indication on PERCENT MODULATION meter.

5-38. AUTOMATIC OUTPUT LEVELING ADJUSTMENT.

a. Connect dc voltmeter (50-volt range) to junction of CR26-R235 (Figure 5-14) and ground.

b. Set RF OUTPUT control fully counterclockwise and MODULATION selector to CW.

c. Adjust R204 (Figure 5-14) to point where dc voltmeter shows no further voltage increase with adjustment of R204.

d. Dc voltmeter should indicate +32.5 ±2.5 volts.

e. Set MODULATION selector to 400~, 1000~, and AM positions; dc voltmeter should indicate +32.5 ±2.5 volts at each switch position.

f. Set MODULATION selector to PULSE/SET RF OUTPUT; voltmeter should indicate +14 ± 1.5 volts.

g. Set MODULATION selector to PULSE; voltmeter should indicate +25 ±2 volts.

h. Set RF OUTPUT control fully clockwise.

i. Set MODULATION selector to CW and PULSE/SET RF OUTPUT positions; dc voltmeter should indicate -0.5 ±0.2 volt dc at each switch position:

j. Set MODULATION selector to PULSE; voltmeter should indicate +25 ± 2 volts.

5-39. RF OSCILLATOR ADJUSTMENT.

a. Connect Signal Generator in test setup shown in Figure 5-3.

b. Set FREQUENCY RANGE switch to band A.

c. Center FINE FREQ and cursor controls.

d. Adjust frequency control for 22 Mc.

e. Check counter frequency indication; counter should indicate 22 Mc ±0.5% (±110 Kc). If not, adjust capacitor C59 (Figure 5-15) for proper counter indication.

f. Repeat steps b through e for each of the following frequencies, adjusting C59 for the best compromise at the listed frequencies:

Band	Frequency
B	43 Mc
C	95 Mc
D	216 Mc
E	480 Mc

5-40. UNCALIBRATED RF OUTPUT, MINIMUM RF OUTPUT, AND RF AMPLIFIER TRACKING ADJUSTMENT.

a. Connect Signal Generator in test setup shown in Figure 5-4, but delete 10-db attenuator.

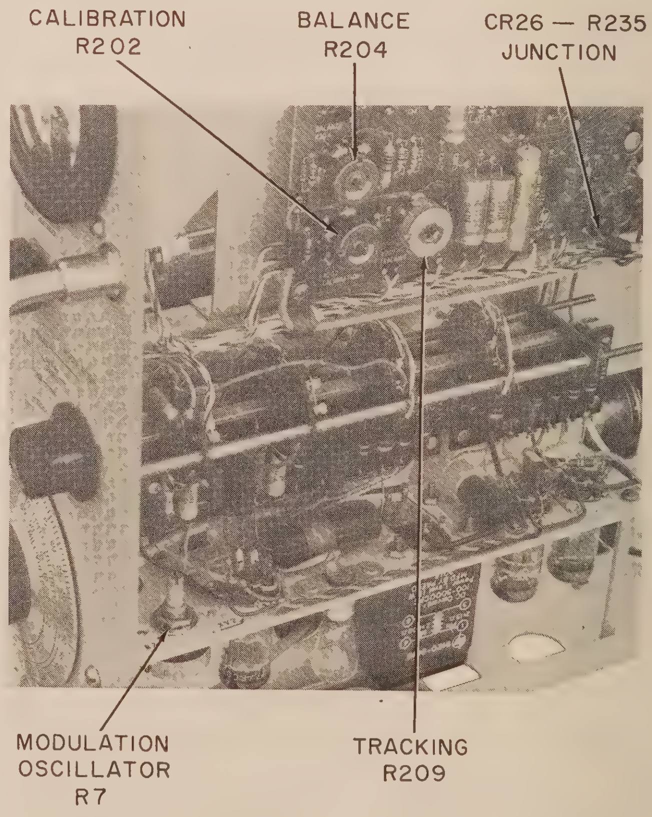


Figure 5-14. Location of Leveling and RF Output Meter Adjustments

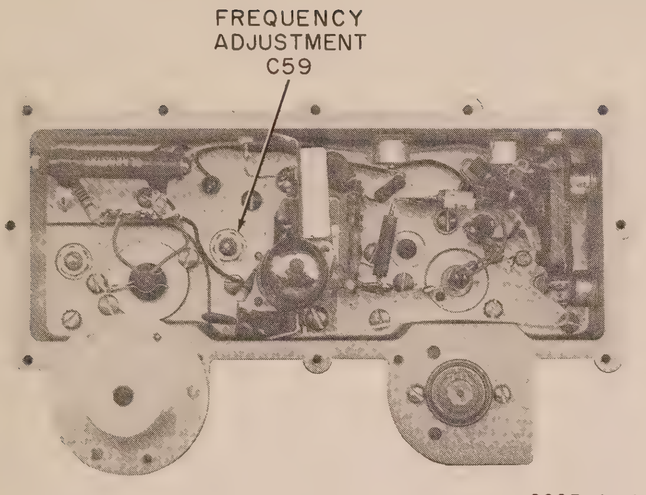


Figure 5-15. Location of RF Oscillator Adjustments

b. Set FREQUENCY RANGE switch to band A.

c. Rotate frequency control through entire range plus one-half turn at edges of band, while adjusting AMPL TRIMMER for maximum RF output. Observe Model 431B Power Meters for following indications:

UNCAL RF OUTPUT: -0.95 dbm min
RF OUTPUT: +13 dbm min

Note

AMPL TRIMMER control should peak with at least one-quarter turn adjustment at either end.

d. If necessary, the power amplifier tuning coils can be adjusted to obtain the proper output at the RF OUTPUT connector, as follows:

Band A: Reposition 3 or 4 turns on coil
Band B through D: Reposition shorted turns on coils
Band E: Spread or compress coil loop

e. Repeat steps b through d for each frequency band, B through E.

5-41. RF OUTPUT METER ACCURACY ADJUSTMENT.

5-42. MECHANICAL ZERO. Adjust mechanical zero as follows:

a. Set MODULATION selector to CW.

b. Connect shorting leads across PERCENT MODULATION meter.

c. Adjust mechanical zero-adjust screw clockwise until pointer is at left of meter zero and moving towards meter zero. Stop adjustment when meter needle is exactly at zero. If needle overshoots, repeat adjustment.

5-43. ELECTRICAL ADJUSTMENT. Proceed as follows:

a. Connect Signal Generator in test setup shown in Figure 5-5.

b. Adjust Signal Generator controls as follows:

Attenuator control	-1.0 dbm
FREQUENCY RANGE	band C
Frequency Control	77.5 Mc
AMPL TRIMMER	max. RF power

c. Adjust RF OUTPUT control for following indication on Model 431B Power Meter and observe RF OUTPUT meter indication. If necessary, perform listed adjustment to obtain proper RF OUTPUT meter reading:

Power Meter Indication (dbm)	RF Output Meter (dbm)	Adjust (Figure 5-14)
+3.0	+13.0	R202
-6	+ 4.0	R209
+3	+13.0	R202
-6	+ 4.0	R209
0	+ 9.8 to +10.2	None
-3	+ 6.8 to +7.2	None

5-44. RF OUTPUT METER/ATTENUATOR FREQUENCY RESPONSE AND AUTOMATIC-LEVELING OUTPUT ADJUSTMENT.

a. Connect Signal Generator in test setup shown in Figure 5-5, but delete 10-db attenuator.

b. Adjust AMPL TRIMMER for best tracking compromise over bands A through D.

c. Adjust RF OUTPUT control for ATTEN CALIBRATED (+7 dbm) indication on RF OUTPUT meter.

d. Vary frequency control over entire frequency range of bands A through D, without further adjustment of AMPL TRIMMER. RF OUTPUT meter indication should remain constant within ±1 db over entire frequency range of bands A through D.

e. Set FREQUENCY RANGE switch to band E.

f. Adjust frequency control to lower end of band, and adjust AMPL TRIMMER for maximum RF output.

g. Adjust frequency control over lower half of band E. Power meter indication should remain constant within ±1 db over lower half of band E.

h. Adjust frequency control to middle of band E, and adjust AMPL TRIMMER for maximum RF output.

i. Adjust frequency control over upper half of band E. Power meter indication should remain constant within ±1 db over upper half of band E.

j. Repeat steps b and c.

k. Set attenuator and FREQUENCY RANGE as follows and observe Model 431B Power Meter for proper indication:

Note

When checking attenuator on band E, readjust AMPL TRIMMER for maximum RF output and then adjust RF OUTPUT control for +7 dbm on RF OUTPUT meter.

Attenuator Setting (dbm)	Frequency Range Band	Power Output (dbm)
-1.0	C	0 to -2.0
-1.0	A	0 to -2.0
-1.0	B	0 to -2.0
-1.0	D	0 to -2.0
-1.0	E	0 to -2.0
-7.0	E	-6.0 to -8.0
-7.0	D	-6.0 to -8.0
-7.0	C	-6.0 to -8.0
-7.0	B	-6.0 to -8.0
-7.0	A	-6.0 to -8.0

m. If the power output is not within the above specified limits, observe which curve of Figure 5-16 is followed by the power output indication on the Model 431B Power Meter. Make appropriate adjustments of coil L17 or resistor R60 (Figure 5-17). If L17 or R60 are adjusted, repeat RF OUTPUT meter adjustments, paragraph 5-41.

5-45. CRYSTAL CALIBRATOR ADJUSTMENT.

a. Remove Signal Generator chassis from cabinet, and remove side plate from RF generator housing.

b. Plug headset into XTAL CAL OUTPUT jack.

c. Set Signal Generator controls as follows:

FREQUENCY RANGE .... between bands
XTAL CAL GAIN .... max. cw
XTAL CAL .... 1 Mc

d. Adjust L18 (Figure 5-17) in clockwise direction. Two separate beat frequencies should be heard in headset within one full turn of L18. Adjust L18 to audible null in first beat note obtained.

e. Set Signal Generator controls as follows:

FREQUENCY RANGE .... band E
RF OUTPUT control .... max. cw

f. Adjust frequency control from 475 to 480 Mc. Six beat notes should occur over this 5-Mc range.

g. Set XTAL CAL to 5 Mc.

h. Adjust frequency control from 475 to 480 Mc. Two beat notes should occur, one at 475 Mc and one at 480 Mc.

5-46. TROUBLESHOOTING.

5-47. PURPOSE. The following paragraphs explain: first, how to isolate a malfunction to a circuit section of the Signal Generator; second, how to isolate a malfunction to a circuit within a section using test points shown on schematic diagrams and third, how to test transistors in operating circuits using a voltmeter (see paragraph 5-70).

5-48. TEST EQUIPMENT REQUIRED. The test equipment required to troubleshoot the Signal Generator is listed in Table 5-2. Instruments other than those listed may be used provided their specifications equal or exceed the critical specifications.

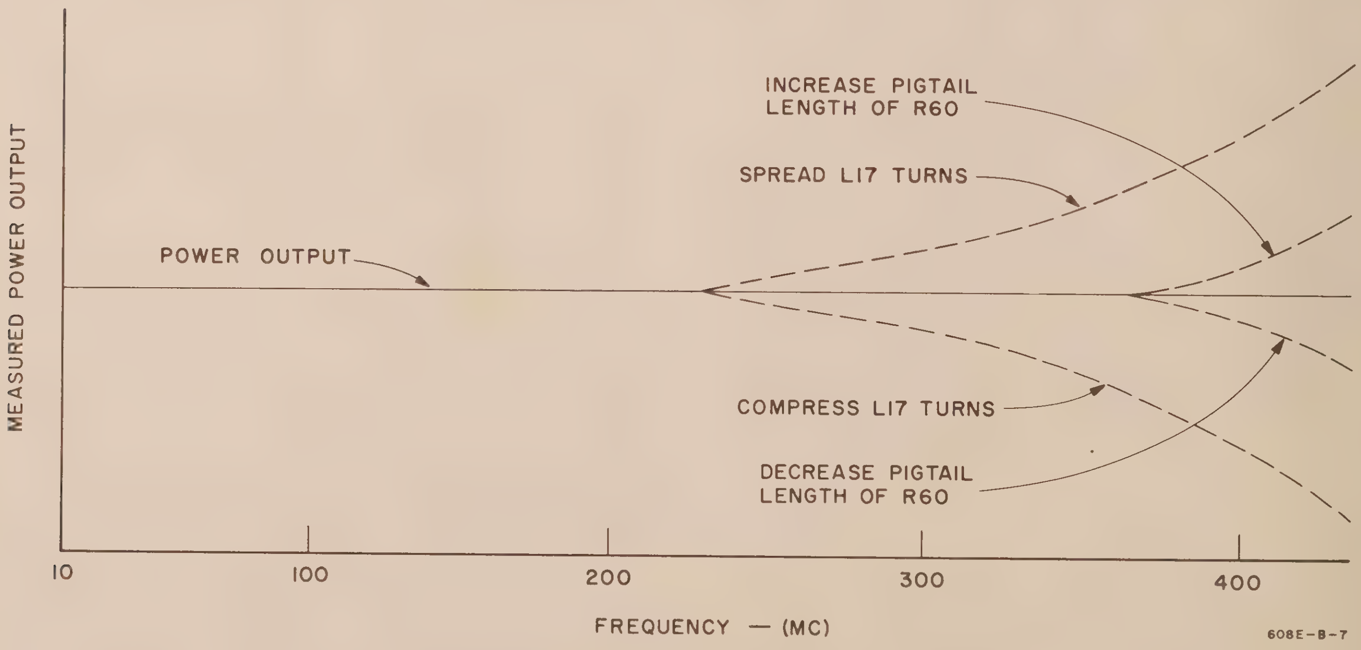


Figure 5-16. Frequency-Response Adjustments

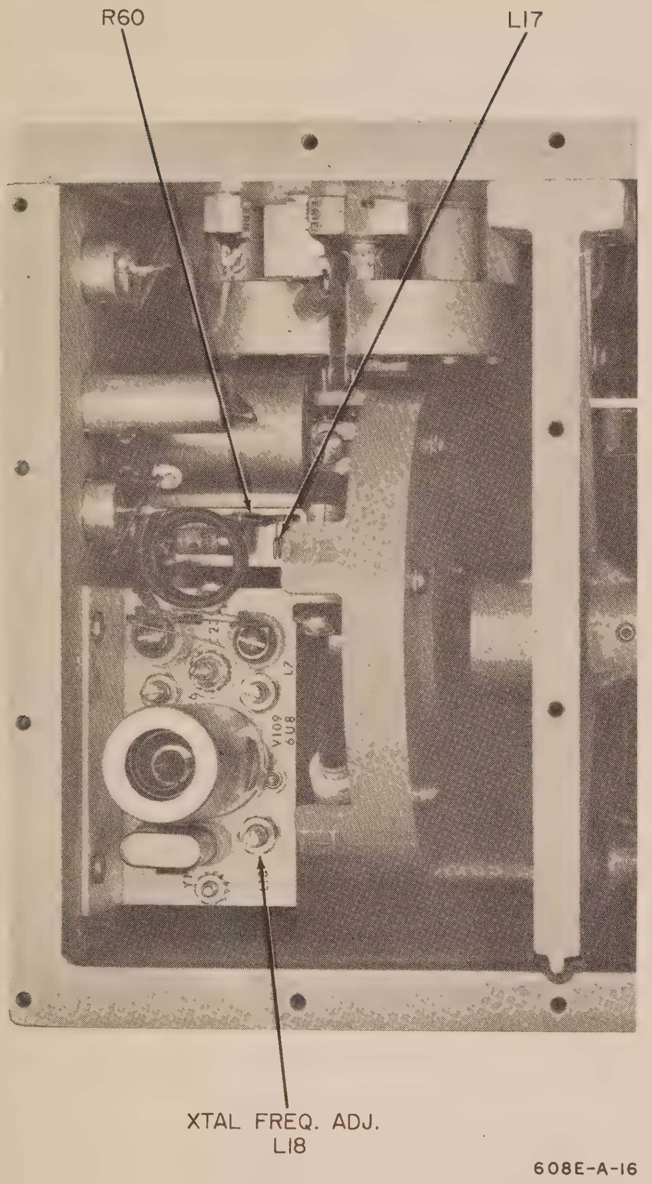


Figure 5-17. Location of Frequency-Response and Crystal-Calibrator Adjustments

5-49. ISOLATING A TROUBLE TO A CIRCUIT SECTION.

5-50. GENERAL. The following troubleshooting procedure is not intended to correct for small out-of-tolerance conditions detected by the performance checks or other means, but is directed towards correcting a complete loss of a major function. The loss of a major function of the Signal Generator will appear as one or more of the following symptoms.

a. No or very low RF output level.

b. Excessive RF output with RF OUTPUT control having little or no affect on RF level.

c. No or very low modulation of RF output, with RF output normal.

d. Abnormal indication on PERCENT MODULATION meter but RF is normally modulated.

e. No beat note at XTAL CAL OUTPUT connector but RF output is normal or nearly normal.

5-51. Each of the above troubles first require isolation to a faulty functional section of the Signal Generator. Regardless of the trouble encountered, the power supply voltages should first be checked (see paragraph 5-57). If a power supply is within 4 or 5% of its nominal value, it should not cause any catastrophic trouble. However, a greater deviation from nominal could be suspected as the cause of a near complete failure of a Signal Generator function. If a voltage value exceeds 4% of its nominal level, the power supply should be repaired prior to troubleshooting the other circuits of the instrument.

5-52. NO OR LOW RF OUTPUT. Assuming the power supply is normal, no or very low RF output could be caused by failure of any of three functional sections: the Attenuator, the RF Generator, or the Modulator. The Modulator is dc coupled to the cathode of the Power Amplifier (V8) and hence a failure in the Modulator could cause a cutoff voltage to be present at the cathode. If it has definitely been established that a very low or no RF output is present at the RF OUTPUT connector (see paragraph 5-19 for this test), set the MODULATION selector to PULSE/SET RF OUTPUT and attempt to adjust the RF OUTPUT and AMPL TRIMMER controls for at least +7 dbm on the RF OUTPUT meter. If this adjustment is normal, the Attenuator or Modulator is at fault. To isolate the trouble, perform the tests in paragraph 5-19, but set MODULATION selector to PULSE/SET RF OUTPUT instead of CW. If the test proves normal, that portion of the Modulator used for CW operation is faulty; see paragraph 5-64. Otherwise, the Attenuator is faulty; see paragraph 5-88. If at least +7 dbm cannot be obtained on the RF OUTPUT meter, set the MODULATION selector to CW, adjust the RF OUTPUT control to its maximum clockwise position, and check the dc voltage at test point 15. Less than +1 volt should be present; if not, the Modulator is faulty (see paragraph 5-64). If the voltage at test point 15 is normal, it can be assumed that the RF Generator is faulty (see paragraph 5-63).

5-53. EXCESSIVE RF OUTPUT WITH POOR CONTROL. A high RF output level with little or no control by adjustment of the RF OUTPUT control indicates a short to ground in the cathode circuit of the RF Power Amplifier (V8) or a failure in the Modulator Section. In the former case, the resistance to ground at test point 15 should be approximately 300K ohms, and 2000 ohms with the ohmmeter leads reversed. If a faulty indication is obtained, diode CR7 should be the first part checked. To troubleshoot the Modulator Section, refer to paragraph 5-64.

5-54. MODULATION TROUBLES. No or very low modulation level (see paragraphs 5-23, 5-24, and 5-27 for this test) but normal RF output is indicative of a trouble in the Modulator Section; refer to paragraph 5-64. An abnormal indication on the PERCENT MODULATION meter (see paragraph 5-23 for this test) with normal modulation present at the RF output is indicative of trouble in the Modulation Meter Section; refer to paragraph 5-66.

5-55. CRYSTAL CALIBRATOR TROUBLES. No beat note at the XTAL CAL OUTPUT connector (see paragraph 5-15 for this test) but normal RF output is indicaative of a trouble in the Calibrator Section; refer to paragraph 5-67.

5-56. Out of-tolerance type troubles can be attributed to two causes: a sudden change in value or failure of a part, or a gradual degradation of instrument performance over a relatively long time period. With the former cause, the functional section most likely to create the condition should be determined by analysis of the Signal Generator circuits. In the latter case, it is feasible that a realignment could cure the out-of-tolerance condition. In general, it is safe to assume that a part has failed if a sudden change occurs in any output characteristic of the Signal Generator, Realignment should be performed only after the trouble has been repaired.

5-57. POWER SUPPLY SECTION. Because the individual power supplies are to some extent interdependent, care must be taken to troubleshoot the supplies in a particular sequence. This sequence is as follows: -165-volt supply, +225-volt supply, +25-volt supply, and -6.3 volt supply.

5-58. To isolate a trouble in the -165-volt supply, check the voltage at test point 16. Excessive ripple is probably due to failure of capacitor C42, C43, or C44, or a heater-to-cathode short in V14 or V16. If the voltage at test point 16 is nonexistent or very low, check the dc voltage between test points 16 and 17 to establish that the dc input (approximately 265 volts) to the regulator is normal. If normal, the trouble is in the regulator circuit composed of V14, V15, and V16 with associated parts. Isolate the faulty tube or part through the use of voltage and resistance checks (Figure 5-24), and tube replacement. It should be noted that the regulator circuit comprises a servo (feedback) loop, and hence a failure of any part will be reflected by erroneous voltage indications at most points in the circuit. Resistance reading, however, usually provide an indication of the faulty part.

5-59. It should be established that an excessive load is not being placed on the power supplies, such as a shorted B+ decoupling capacitor or shorted tube. Excessive load conditions give trouble symptoms similar to those encountered in a power supply failure. A Model 428 ammeter can be used to check the current load on the supplies. The following lists the check points for each power supply:

Power Supply	*Current	Test Point
-165	110 ±11 ma	Grey wire to R125
+225	110 ±11 ma	Violet wire to R124
+25	30 ± 3 ma	Orange wire on T2
-6.3	860 ±86 ma	Violet wire between collector of Q1 and CR18

*MODULATION selector at CW, RF OUTPUT fully cw, FREQUENCY RANGE at band E.

5-60. If the dc voltage input to the regulator circuit is abnormal, check the ac voltage between test points 18 and 19. If this voltage is normal, bridge rectifier diodes CR12-CR15, capacitor C42, or resistor R125 is faulty. If the ac voltage across test points 18 and 19 is abnormal, transformer T1 is faulty or the 115 (or 230) volt primary power is abnormal.

5-61. Each of the other power supplies is checked in a manner similar to the -165-volt supply, using the particular test points assigned to these supplies. Care must be taken to follow the sequence given in paragraph 5-57. The +225-volt supply has a fuse, F3, in series with its output. This fuse should be the first part checked when troubleshooting the +225-volt supply. The +25- and -6.3-volt supplies use transistors and breakdown-diode regulator circuits. When troubleshooting these power supplies, measure the voltage drop across the breakdown diodes (test points 32 and 33) to ensure the diodes are not faulty. The transistors are best checked by the methods described in paragraph 5-70.

5-62. ATTENUATOR SECTION. When it has been established by the procedures outlined in paragraph 5-52 that the Attenuator is faulty, refer to paragraph 5-88 for repair procedures.

5-63. RF GENERATOR SECTION. To establish that the Oscillator and its output stages are normal, make a measurement of the RF output (see paragraph 5-22) at test point 2. If the indication is normal, it can be assumed that the Oscillator is normal and the fault is in the Buffer or Power Amplifier. Further voltage and resistance checks (see Figure 5-24) will isolate the faulty part or tube. Refer to paragraph 5-81 if it is necessary to replace a tube in the RF Generator Section.

5-64. MODULATOR SECTION. Troubles in the Modulation Section are divided into two categories: RF level troubles, and modulation troubles. An RF level trouble can be low or high RF output, with the latter combined with poor action of the RF OUTPUT control. Both of these RF troubles indicate a complete failure of a part and are fault-isolated in the same manner, namely by performing the transistor (Q2 through Q9) voltage measurements given in Figure 5-24. When an abnormal voltage indication occurs, check and, if necessary, replace the faulty transistor or part. Modulation troubles consist of internal, external, or pulse-modulation troubles. If all but internal modulation are normal, oscillator V2 and associated parts should be suspected. If both internal and external sine-wave modulation are faulty, but pulse modulation is normal, the fault probably exists in transistor stages Q2, Q3, and Q4. If all modulating modes are faulty, transistors Q5 through Q9 or associated parts are probably at fault. If only pulse modulation is faulty, transistor Q5 and/or diodes CR23 and CR24 are at fault. If the modulator is modulating the RF but appears to have low gain (insufficient modulation percentage) check the peak-to-peak amplitude of the 400- or 1000-cps sine wave at test points 10 through 15 as follows:

Test Point	Peak-To-Peak* Amplitude (volts)
10	0.5
11	0.1
12	0.35
13	1.75
14	8.0
15	8.0

5-65. If a faulty indication occurs at any test point, check both the preceding and following transistor stages and associated parts. Paragraph 5-68 describes transistor checks.

5-66. MODULATION METER SECTION. To isolate a trouble in the Modulation Meter Section, set the MODULATION selector to 1000~ and adjust the MODULATION control for maximum modulation of the RF output. Check for a 1000-cps sine wave at test point 6. If the waveform is abnormal, the trouble is in detector CR2 or associated parts. If normal, check waveforms at test points 7 and 8 to establish that Amplifiers V18 and V19 are not at fault. If an abnormal indication appears at test points 7 or 8, perform voltage and resistance checks on the appropriate amplifier or, if necessary, replace V18 and/or V19. If normal indications are observed at test points 7 and 8, check dc voltage at test point 9 while varying the MODULATION control; dc voltage should vary accordingly. If the indication is abnormal, rectifier V20 is faulty; otherwise, the trouble is in the Meter Bridge circuit composed of V21, the PERCENT MODULATION meter, or associated parts.

5-67. CALIBRATOR SECTION. To isolate a trouble in the calibrator, set the XTAL CAL switch to 1 Mc and check for an audio sine wave at test point 3 while carefully adjusting the frequency dial over a 5-Mc sector. The sine wave should null at 1-Mc intervals. If not, the trouble is in Crystal Oscillator V9 or Harmonic Generator CR1. Further voltage and resistance checks (see Figure 5-24) or replacement of V9 or CR1 should correct the deficiency. If the nulling indication is normal, Amplifier V10, V11, or associated parts are faulty. Further sine-wave measurements at test points 4 and 5 should isolate the faulty amplifier stage.

5-68. ISOLATING TROUBLE IN TRANSISTOR CIRCUITS.

5-69. The following procedures and data are given to aid in determining whether a transistor is operational. Tests are given for both in-circuit and out-of-circuit transistors.

5-70. IN-CIRCUIT TESTING. The common causes of transistor failures are internal short- and open-circuits. In transistor circuit testing the most important consideration is the transistor base-emitter junction. Like the control grid of a vacuum tube, this is the operational control point in the transistor. This junction is essentially a solid-state diode. For the transistor to conduct, the diode must conduct; that is, the diode must be forward biased. As with simple diodes, the forward-bias polarity is determined by the materials forming the function. Use the transistor symbol on the schematic diagram to determine the bias polarity required to forward-bias the base-emitter junction. The A part of Figure 5-18 shows transistor symbols with terminals labeled. Notice that the emitter arrow conventionally points toward the type N material. The other two columns of the illustration compare the biasing required to cause conduction and cut-off in transistors and vacuum tubes. If the transistor base-emitter diode (junction) is forward-biased the transistor conducts. If the diode is heavily forward-biased, the transistor saturates. However, if the base-emitter diode is reverse-biased the transistor is cut-off. The voltage drop across a forward biased emitter-base diode varies with transistor collector current. For example, a germanium transistor has a typical forward-bias, base-emitter voltage of 0.2 - 0.3 volt when collector current is 1 - 10 ma, and 0.4 - 0.5 volt when collector current is 10 - 100 ma. In contrast, forward bias voltage for silicon transistors is about twice that for germanium types: about 0.5 - 0.6 volt when collector current is low, and about 0.8 - 0.9 volt when collector current is high.

5-71. Figure 5-18, part B, shows simplified versions of the three basic transistor circuits and gives the operating characteristics of each. When examining a transistor stage, first determine if the emitter-base diode is biased for conduction (forward-biased) by measuring the voltage difference between emitter and base. When using an electronic voltmeter, do not measure directly between emitter and base: there may be sufficient loop current between the voltmeter leads to damage the transistor. Instead, measure to a common point (e.g., chassis). If the emitter-base diode is forward-biased, check for amplifier action by short-circuiting base to emitter while observing collector voltage. The short-circuit eliminates base-emitter bias and should cause the transistor to stop conducting (cut off). Collector voltage should then shift to near the supply voltage. Any difference is due to leakage current through the transistor and, in general, the smaller this current, the better the transistor. If collector voltage does not change, the transistor may have either an emitter-collector short circuit or emitter-base open circuit.

5-72. TESTING TRANSISTORS WITH AN OHMMETER. The two common causes of transistor failure are internal short- and open-circuits. Remove the transistor from the circuit and use an ohmmeter to measure internal resistance. See Table 5-3 for measurement data.

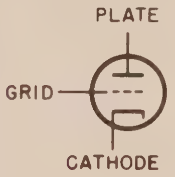
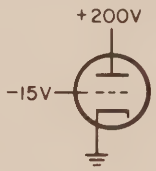
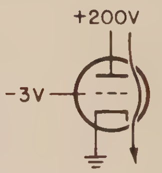
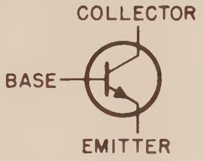
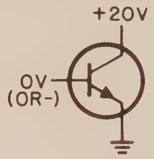
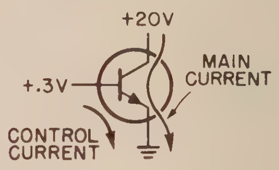
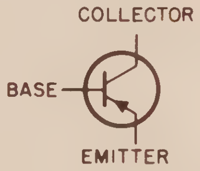
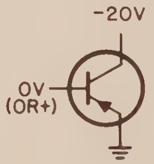
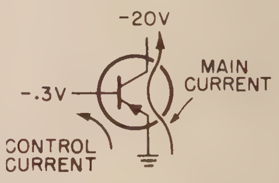
CAUTION

Most ohmmeters can supply enough current or voltage to damage a transistor. Before using an ohmmeter to measure transistor forward or reverse resistance, check open-circuit voltage and short-circuit current output ON THE RANGE TO BE USED. Open-circuit voltage must not exceed 1.5 volts and short-circuit current must be less than 3 ma. See Table 5-4 for safe resistance ranges for some common ohmmeters.

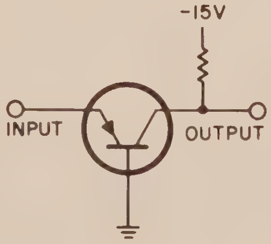
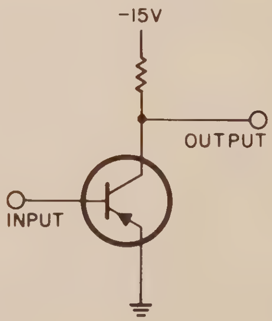
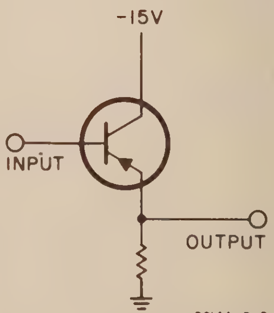
---

*MODULATION control adjusted for 2.5 volt peak-to-peak sine wave at base of Q3.

A. TRANSISTOR BIASING

DEVICE	SYMBOL	CUT OFF	CONDUCTING
VACUUM TUBE			
N P N TRANSISTOR			
P N P TRANSISTOR			

B. AMPLIFIER CHARACTERISTICS

CHARACTERISTIC	COMMON BASE	COMMON EMITTER	COMMON COLLECTOR
INPUT Z	30-50 Ω	500-1500 Ω	20-500K Ω
OUTPUT Z	300-500K Ω	30-50K Ω	50-1000 Ω
VOLTAGE GAIN	500-1500	300-1000	< 1
CURRENT GAIN	< 1	25-50	25-50
POWER GAIN	20-30 db	25-40 db	10-20 db
			

9614A-B-8

Figure 5-18. Transistor Biasing and Operating Characteristics

Figure 5-3. Out-of-Circuit Transistor Resistance Measurement

Transistor Type		Connect Ohmmeter		Measure Resistance (ohms)
		Pos. lead to	Neg. lead to	
PNP Germanium	Small Signal	emitter	base*	200 - 500
		emitter	collector	10K - 100K
	Power	emitter	base*	30 - 50
		emitter	collector	several hundred
NPN Silicon	Small Signal	base*	emitter	1K - 3K
		collector	emitter	very high (might read open)
	Power	base	emitter	200 - 1000
		collector	emitter	high, often greater than 1 M

*To test for transistor action, add collector-base short. Measured resistance should decrease.

5-73. ETCHED CIRCUITS.

5-74. GENERAL PROCEDURES.

5-75. The etched circuit boards in the Signal Generator are of the plated-through type consisting of metallic conductors bonded to both sides of insulating material. The metallic conductors are extended through the component mounting holes by a plating process. Soldering can be done from either side of the board with equally good results. Table 5-5 lists recommended tools and materials. Following are recommendations and precautions pertinent to etched circuit repair work.

a. Avoid unnecessary component substitution; it can result in damage to the circuit board and/or adjacent components.

b. Do not use a high-power soldering iron on etched circuit boards. Excessive heat may lift a conductor or damage the board.

c. Use a suction device (see Table 5-5) or wooden toothpick to remove solder from component mounting holes. DO NOT USE A SHARP METAL OBJECT SUCH AS AN AWL OR TWIST DRILL FOR THIS PURPOSE. SHARP OBJECTS MAY DAMAGE THE PLATED-THROUGH CONDUCTOR.

d. After soldering, remove excess flux from the soldered areas and apply a protective coating to prevent contamination and corrosion. See Table 5-5 for recommendations.

5-76. COMPONENT REPLACEMENT.

a. Remove defective component from circuit board.

b. Remove solder from mounting holes using a suction desoldering aid (Table 5-5) or wooden toothpick.

c. Shape leads of replacement component to match mounting hold spacing.

d. Insert component leads into mounting holes, and position component as original was positioned. DO NOT FORCE LEADS OF REPLACEMENT COMPONENT INTO MOUNTING HOLES. Sharp lead ends may damage plated-through conductor.

Note

> Axial lead components, such as resistors and tubular capacitors, can be replaced without unsoldering. Clip leads near body of defective component, remove component and straighten leads left in board. Wrap leads of replacement component one turn around original leads. Solder wrapped connection, and clip off excess lead.

5-77. ETCHED CONDUCTOR REPAIR.

5-78. A broken or burned section of conductor can be repaired by bridging the damaged section with a length of tinned copper wire. Allow adequate overlap and remove any varnish from etched conductor before soldering wire into place.

5-79. TRANSISTOR AND SEMICONDUCTOR DIODE REPLACEMENT.

a. Do not apply excessive heat. See Table 5-5 for soldering tool specifications.

Table 5-4. Safe Ohmeter Ranges for Transistor Resistance Measurements

Ohmmeter	Safe Range(s)	Open Ckt Voltage	Short Ckt Current	Lead	
				Color	Polarity
412A	R x 1K	1.0V	1 ma	Red Blk	+ -
	R x 10K	1.0V	100 μa		
	R x 100K	1.0V	10 μa		
	R x 1M	1.0V	1 μa		
	R x 10M	1.0V	0.1 μa		
410C	R x 1K	1.3V	0.57ma	Red Blk	+ -
	R x 10K	1.3V	57 μa		
	R x 100K	1.3V	5.7 μa		
	R x 1M	1.3V	0.5 μa		
	R x 10M	1.3V	0.05μa		
410B	R x 100	1.1V	1.1 ma	Blk Red	+ -
	R x 1K	1.1V	110 μa		
	R x 10K	1.1V	11 μa		
	R x 100K	1.1V	1.1 μa		
	R x 1M	1.1V	0.11 μa		
Simpson 260	R x 100	1.5V	1 ma	Red Blk	+ -
Simpson 269	R x 1K	1.5V	0.82 ma	Blk Red	+ -
Triplett 630	R x 100	1.5V	32 ma	Varies with Serial Number	
	R x 1K	1.5V	3.25 ma		
Triplett 310	R x 10	1.5V	750 μa		
	R x 100	1.5V	75 μa		

Table 5-5. Etched Circuit Soldering Equipment

Item	Use	Specification	Item Recommended
Soldering Tool	Soldering Unsoldering	Wattage rating: 37.5 Tip Temp: 750-800°F Tip Size: 1/8" OD	Ungar #776 Handle with Ungar #1237 Heating Unit
Soldering Tip,	Soldering	Shape: chisel	Ungar #PL113
General Purpose	Unsoldering	Size: 1/8"	
De-soldering aid	Unsoldering multi-connection components (e.g., tube sockets)	Suction device to remove molten solder from connection	Soldapult by the Edsyn Company, Arleta, California
Resin (flux) solvent	Remove excess flux from soldered area before application of protective coating	Must not dissolve etched circuit base board material or conductor bonding agent	Freon Acetone Lacquer Thinner Isopropyl Alcohol (100% dry)
Solder	Component replacement Circuit board repair Wiring	Resin (flux) core, high tin content (60/40 tin/lead), 18 gauge (SWG) preferred	
Protective Coating	Contamination, corrosion protection after soldering	Good electrical insulation, corrosion-prevention properties	Krylon #1302* Humiseal Protective Coating, Type 1B12 by Columbia Technical Corp. Woodside 77, New York

*Krylon, Inc., Norristown, Pennsylvania

b. Use a heat sink, such as pliers, between semiconductor body and hot soldering iron.

c. When installing a replacement semiconductor ensure sufficient lead length to dissipate heat of soldering by maintaining about the same length of exposed lead as used for original semiconductor.

d. Refer to Table 5-6 for checks following replacement of a semiconductor.

5-80. REPAIR.

5-81. REPLACEMENT OF ELECTRON TUBES.

5-82. When replacing tubes in the Model 608E, it is recommended that a check be made of the operation of the instrument before and after each tube trial and, if no improvement is noted, the original tube be returned to the socket. Figure 5-19 locates all electron tubes in the equipment. Table 5-6 lists all tubes, together with the checks which should be made following tube replacement.

5-83. OSCILLATOR TUBE REPLACEMENT. Replacement of RF Oscillator tube V6 may affect the calibration of the frequency dial and the amplitude of the RF Generator heater-voltage supply. In addition, plate current requirements of type 4042 pencil triodes may differ widely from tube to tube in a given application. Therefore, when V6 is replaced, heater voltage must be checked and, if necessary, reset to the proper value; plate current must be held to between 18 and 27 milliamperes by tube selection; and calibration of the frequency dial must be checked.

5-84. To replace Oscillator V6, refer to Figure 5-20 and proceed as follows:

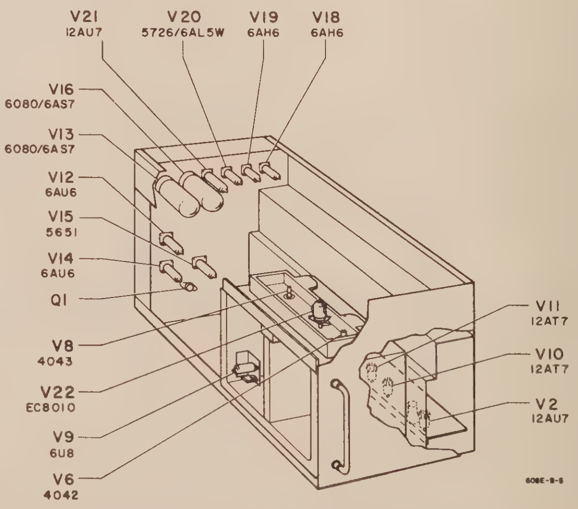


Figure 5-19. Location of Electron Tubes

Table 5-6. Checks Following Tube and Semiconductor Replacement

Reference Designation	Check	Paragraph
V2	Internal Modulation	5-24
V6	Frequency Accuracy	5-14
	Frequency Drift	5-16
	Uncalibrated RF Output	5-22
V8	Maximum RF Output	5-19
V9	Crystal Calibrator Accuracy	5-15
V10	Crystal Calibrator Accuracy	5-15
V11	Crystal Calibrator Accuracy	5-15
V12	Power Supply (+225)	5-32
V13	Power Supply (+225)	5-32
V14	Power Supply (-165)	5-32
V15	Power Supply (-165)	5-32
V16	Power Supply (-165)	5-32
V18	Modulation Meter Accuracy	5-23
V19	Modulation Meter Accuracy	5-23
V20	Modulation Meter Accuracy	5-23
V21	Modulation Meter Accuracy	5-23
V22	Maximum RF Output	5-19
Q1	Power Supply	5-32
Q2	Leveling	5-20
Q3	Leveling	5-20
	Internal Modulation	5-24
Q4	Leveling	5-20
	Internal Modulation	5-24
Q5	Leveling	5-20
	External Pulse Modulation	5-27
Q6	Leveling	5-20
	Internal Modulation	5-24
Q7	Leveling	5-20
	Internal Modulation	5-24
Q8	Leveling	5-20
	Internal Modulation	5-24
Q9	Leveling	5-20
	Internal Modulation	5-24
Q10	Power Supply (+25)	5-32
Q11	Power Supply (+25)	5-32
CR1	Crystal Calibrator Accuracy	5-15
CR2	Modulation Meter Accuracy	5-23
CR7	Leveling	5-20
CR8	Power Supply (+225)	5-32
CR9	Power Supply (+225)	5-32
CR10	Power Supply (+225)	5-32
CR11	Power Supply (+225)	5-32
CR12	Power Supply (-165)	5-32
CR13	Power Supply (-165)	5-32
CR14	Power Supply (-165)	5-32
CR15	Power Supply (-165)	5-32
CR16	Power Supply (-6. 3)	5-32
CR17	Power Supply (-6. 3)	5-32
CR18	Power Supply (-6. 3)	5-32
CR19	Power Supply (-6. 3)	5-32
CR20	Power Supply (-6. 3)	5-32
CR21	Leveling	5-20
CR23	External Pulse Modulation	5-27
CR24	External Pulse Modulation	5-27
CR25	Leveling	5-20
CR26	Leveling	5-20
CR27	Power Supply (+25)	5-32
CR28	Power Supply (+25)	5-32
CR29	Power Supply (+25)	5-32
CR30	Power Supply (+25)	5-32

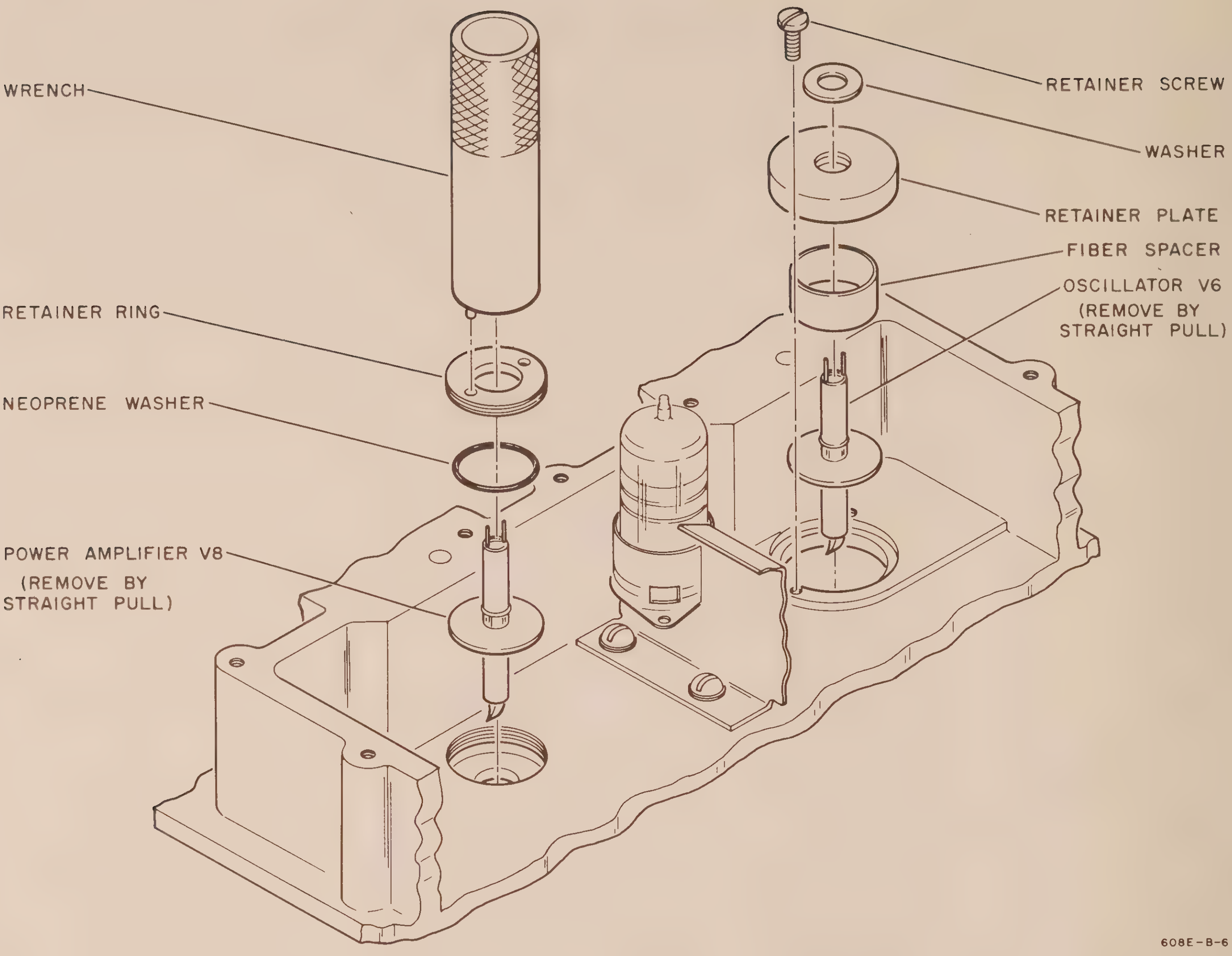


Figure 5-20. Replacement of Oscillator and Amplifier Tubes

a. Remove frequency dial and top plate from RF Generator housing to gain access to tube compartment. (The frequency dial is accurately indexed on its hub by two pins to assure exact positioning when dial is replaced on hub.)

b. Remove socket from base of V6 by straight pull.

c. Remove cathode clip from tube.

d. Remove the two BH screws holding retainer plate, then remove plate and fiber spacer.

e. Lift tube gently from hole by straight pull.

f. Replace tube in reverse order of above steps.

g. Connect a dc voltmeter to inside lead of FL4. Meter should indicate 6.3 Vdc. If necessary, change value of CR20 to obtain 6.3 Vdc.

h. Using Model 428 DC Ammeter, measure current in lead to feed-through capacitor C15.

i. Set the FREQUENCY RANGE switch to band E. Current meter should indicate between 18 and 27 ma. If meter indication is not within these limits, substitute another 4042 oscillator tube.

j. Using internal beat-frequency calibrator, check frequency calibration throughout range of Signal Generator, noting points that are significantly off frequency.

k. To correct calibration at the high-frequency end of all bands simultaneously, adjust trimmer capacitor C18, which is accessible in tube compartment in RF Generator housing. This adjustment has only minor effect at low-frequency ends of all ranges.

5-85. RF AMPLIFIER AND BUFFER TUBE REPLACEMENT. To remove RF Amplifier V8 and Buffer V22, refer to Figure 5-20 and proceed as follows:

Note

Replacement of the RF Amplifier and Buffer tubes can affect the amplitude of the RF generator heater-voltage supply and may limit the power output from the Signal Generator.

a. Remove frequency dial and top plate from RF Generator housing to gain access to tube compartment.

b. Replace Buffer V22.

c. For Amplifier V8, remove socket from base of V8 by straight pull.

d. Remove cathode clip from tube.

e. Using special wrench (located on instrument chassis, near RF Generator housing), loosen threaded retainer ring which holds V8 in housing. Remove retainer ring and neoprene washer.

f. Remove old tube and replace with new type 4043 tube.

g. Check power output throughout full frequency range of Signal Generator. With AMPL TRIMMER set for maximum output at each frequency, a full-scale reading should be obtained over entire frequency range.

5-86. CRYSTAL OSCILLATOR TUBE OR QUARTZ CRYSTAL REPLACEMENT. To gain access to the Calibrator Oscillator, remove the side cover on the RF Generator housing. The entire Crystal Oscillator is mounted on a bracket on the rear wall of the amplifier compartment. Location of oscillator tube V9, crystal Y1, and associated adjustments are shown in Figure 5-28. If V9 or Y1 is replaced, the calibrator should be checked and, if necessary, adjusted.

5-87. The crystal-controlled frequency calibrator is composed of two circuits: the 5-megacycle crystal-controlled oscillator, which utilizes the pentode half of a type 6U8 tube, and the 1-megacycle oscillator, utilizing the triode section of the 6U8. Each section is adjustable, and both sections should be adjusted at the same time. The frequency of the crystal can only be adjusted over a range of approximately 100 cycles. The frequency of the 1-megacycle oscillator then locks in with the 5-megacycle frequency and is either right on frequency of is very far off. To adjust the crystal-controlled calibrator, refer to paragraph 5-45.

5-88. ATTENUATOR PROBE REPAIR AND REPLACEMENT.

CAUTION

During removal and replacement of the probe, extreme care must be exercised. The probe consists of a cylindrical metal tube with a series of spring contact fingers around its periphery at one end. These fingers can be accidentally bent or twisted. It should be noted that one or two of the fingers are bent toward the center of the probe slightly; do not attempt to straighten them, since these fingers have been bent to assure clearance between the probe and the end of the guide slot in the attenuator housing. It is of greatest importance to make certain that the probe is not subjected to shock. If subjected to shock, the electrical components attached to the end of the probe can be broken or their positions altered, with a consequent change in the electrical characteristics of the probe.

5-89. GENERAL. The impedance-matching network in the output attenuator can be damaged if power from an external source is applied to the RF OUTPUT connector. If electrical components of the output attenuator are damaged, repair or replacement is necessary. Damage to the impedance-matching network may be confirmed by measuring the VSWR of the attenuator at the RF OUTPUT connector.

Note

Attenuator VSWR is determined by positioning of the probe variable capacitor (C37) and the relative position of the two resistors (R58 and R59) on the end of the probe. If replacement resistors are returned to their original positions, the VSWR will not be changed appreciably. However, if equipment is available for checking attenuator VSWR, such a check is advisable following replacement of resistors.

5-90. REMOVAL FROM HOUSING. If investigation shows an attenuator to be defective, proceed as follows:

a. Turn attenuator control on front panel until probe reaches end of its travel at rear of attenuator housing.

b. Remove nut and washers that hold drive cable in probe drive screw (Figure 5-21) in top of attenuator probe.

c. Remove probe split drive screw from probe body by removing inner nut and unscrewing.

d. Remove probe by carefully sliding it out of attenuator housing.

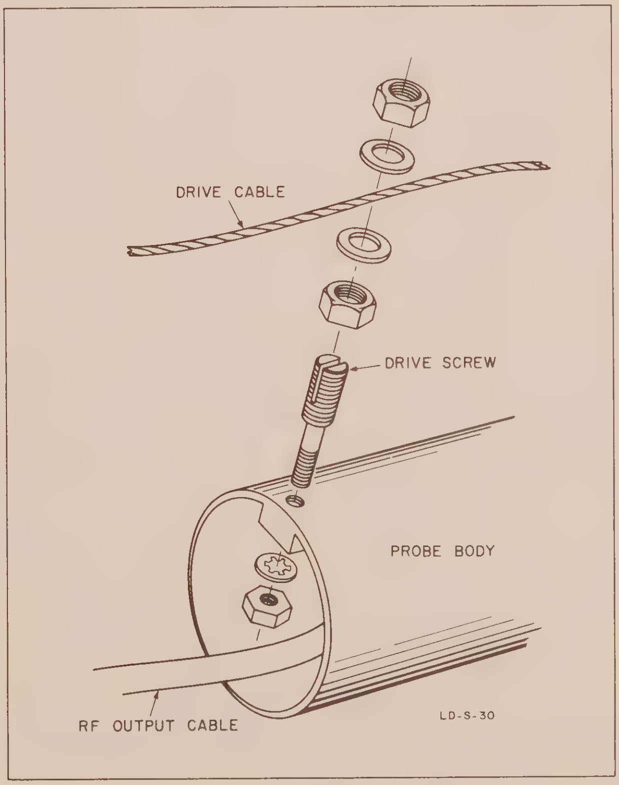


Figure 5-21. Disassembly of Attenuator Drive Cable

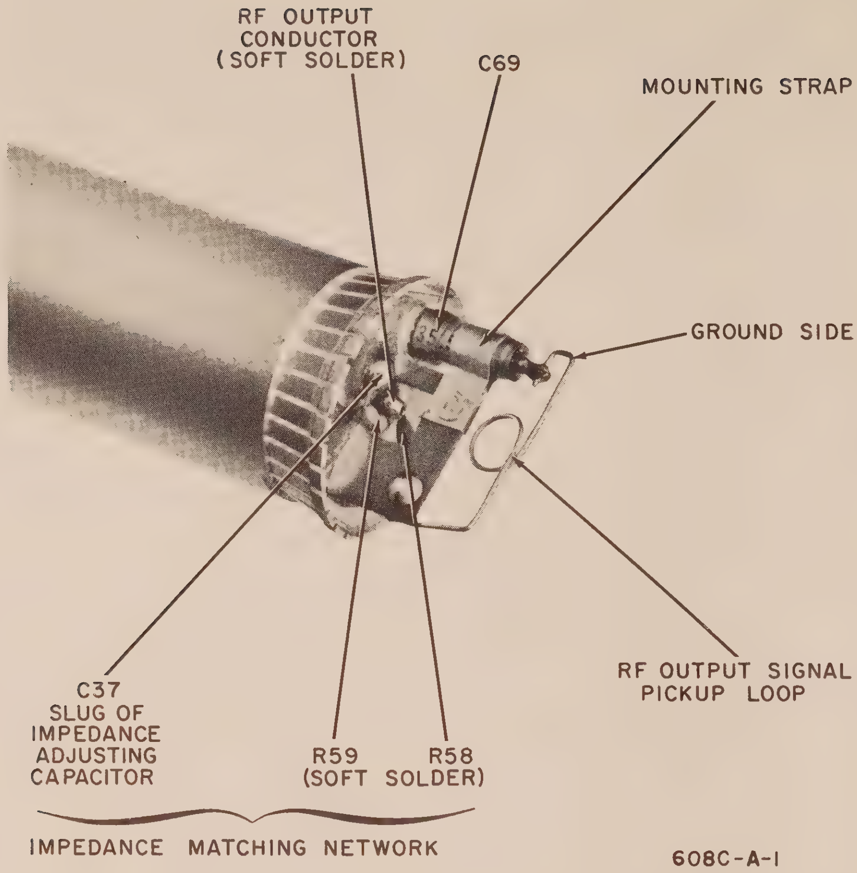

RF OUTPUT CONDUCTOR (SOFT SOLDER)
C69
MOUNTING STRAP
GROUND SIDE
RF OUTPUT SIGNAL PICKUP LOOP
C37 SLUG OF IMPEDANCE ADJUSTING CAPACITOR
R59
R58 (SOFT SOLDER)
IMPEDANCE MATCHING NETWORK
608C-A-1

Figure 5-22. Attenuator Probe, Showing Pickup Loop and Impedance Matching Network

5-91. PROBE REPAIR. Capacitor C69 (Figure 5-22) is held in place by a mounting strap and a setscrew. To replace C69, unsolder the pickup loop at the capacitor end (ground slide of loop), loosen the setscrew, and slide the capacitor out of the clamp. Replace by reversing this procedure. The capacitor must be firmly seated in the hole in the end of the probe before tightening the setscrew. Be careful when tightening the setscrew; the capacitor ground lead can be cut in two if the setscrew is tightened excessively.

5-92. Note location of the two resistors so that new ones can be mounted as nearly as possible in the same position. Install new resistors; duplicate the original resistor mounting positions and lead lengths as closely as possible. Make connections without excessive binding or pulling on ends of resistors as they are fragile.

CAUTION

These resistors are easily damaged by excessive heat. Use low-temperature soldering iron and solder connections as quickly as possible.

5-93. Measure resistors for any possible change in resistance due to soldering. The VSWR will not be changed appreciably.

5-94. The VSWR can be checked at several frequencies on band E, and the position of resistors R59 and R58 adjusted for optimum VSWR. Adjustment on the band E will automatically correct for minimum VSWR on the lower bands. Laboratory test equipment, such as an impedance bridge or reflectometer setup, will be required for measuring the VSWR. These VSWR checks must be made with attenuator inserted in attenuator housing in the instrument, as results obtained will be slightly different with attenuator outside of the housing.

5-95. PROBE REPLACEMENT. If repair is not possible, both probe and cable must be replaced. Remove the RF OUTPUT connector from the front panel, and release the cable from the clamp holding the cable to the top of the side gusset. The entire probe assembly may then be removed from the instrument. Replacement probes are complete with cable and panel connector, and require no adjustment of the impedance-matching network upon installation.

5-96. REPLACEMENT IN HOUSING.

a. Insert new or repaired probe in attenuator housing. Care must be taken in starting probe into housing, since diameter at probe contact fingers is slightly greater than inner diameter of housing. Contact fingers should be depressed slightly while starting probe into its housing.

CAUTION

Under no circumstances should the probe be forced.

b. Replace split drive screw in probe, making certain that screw slot is parallel to axis of housing.

c. Set attenuator drive cable in screw slot and replace both washers and nut. Do not tighten nut. Cable must move freely through the slot until probe penetration has been set.

d. Secure RF cable to clamp on side gusset.

e. Connect instrument to a source of 115-volt (or 230 volt) power, and turn on POWER switch. Unless otherwise specified, operating controls should be set as follows:

MODULATION Selector	CW
Frequency dial	70 megacycles
FREQUENCY RANGE	band C
AMPL TRIMMER	Adjust for max. RF output
RF OUTPUT meter	7 dbm
MODULATION control	max. ccw
Attenuator	0 dbm

f. Connect a power meter (such as Model 431B), through a bolometer mount (Model 478A or equivalent), to RF OUTPUT connector.

g. Remove RF Generator side plate so that clearance between attenuator probe and coils of RF Amplifier tank may be observed.

CAUTION

The following step must be executed as carefully as possible to insure that the pickup loop does not make contact with any of the power amplifier coils. These coils are at B+ potential, and contact between any one of them and the attenuator pickup loop will damage attenuator components.

h. With attenuator dial set exactly on 0 dbm, manually advance attenuator probe into the housing until RF output signal is exactly 1 milliwatt (0 dbm) as read on external power meter.

i. Tighten down nut on split drive screw so that probe may be actuated by its drive system. Carefully check to see that there is clearance between various amplifier coils and pickup loop when attenuator dial is set to +7 dbm.

5-97. REPLACEMENT OF LAMP I1.

5-98. Lamp I1 acts as a positive temperature coefficient resistance, maintaining Modulator Oscillator output constant. The characteristics of the type S6 lamps used for this purpose ordinarily vary widely from lamp to lamp, causing a corresponding variation in the amplitude of the oscillator output from one Model 608E to another. To compensate for differences between lamps, potentiometer R7 is provided for adjustment of the oscillator output voltage level. After lamp I1 has been replaced, the oscillator output voltage, as measured at pin 3 of V2, should be adjusted to 2 volts rms; if it cannot be adjusted to this value, another lamp must be tried.

1. Unless otherwise noted, measurements made with respect to chassis ground using VTVM and with front panel controls at the following settings:

Frequency	100 Mc
Modulation Selector	1000 ~
Modulation	50%
RF OUTPUT	+7 dbm
AMPL TRIMMER	max. RF output

   R71 and R80 in the power supply section set to provide the normal supply voltage of +225V and -165V, respectively.

2. A 20,000-ohm-per-volt meter cannot be used for this measurement since it will load the circuit and provide an erroneous reading. A vacuum-tube voltmeter must be used here.

3. Reading taken at minimum and maximum setting of RF OUTPUT control.

4. MODULATION selector at CW, and RF OUTPUT control adjusted for 0.35 volts at its wiper contact.

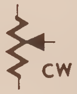
5. Resistance in ohms, capacitance in picofarads unless other indicated.

6. ⊘ screwdriver adjust

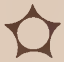
   ○ panel control

7. ▭ front panel designation

8. ——— signal path – – – – feedback path

9. 

CW indicates movable contact position at clockwise rotation limit of control shaft (shaft viewed from knob or slotted end)

10. 
test point

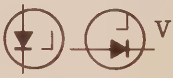
11. 
Voltage regulator (breakdown) diode

Figure 5-23. Notes Pertaining to Schematic and Voltage-Resistance Diagrams

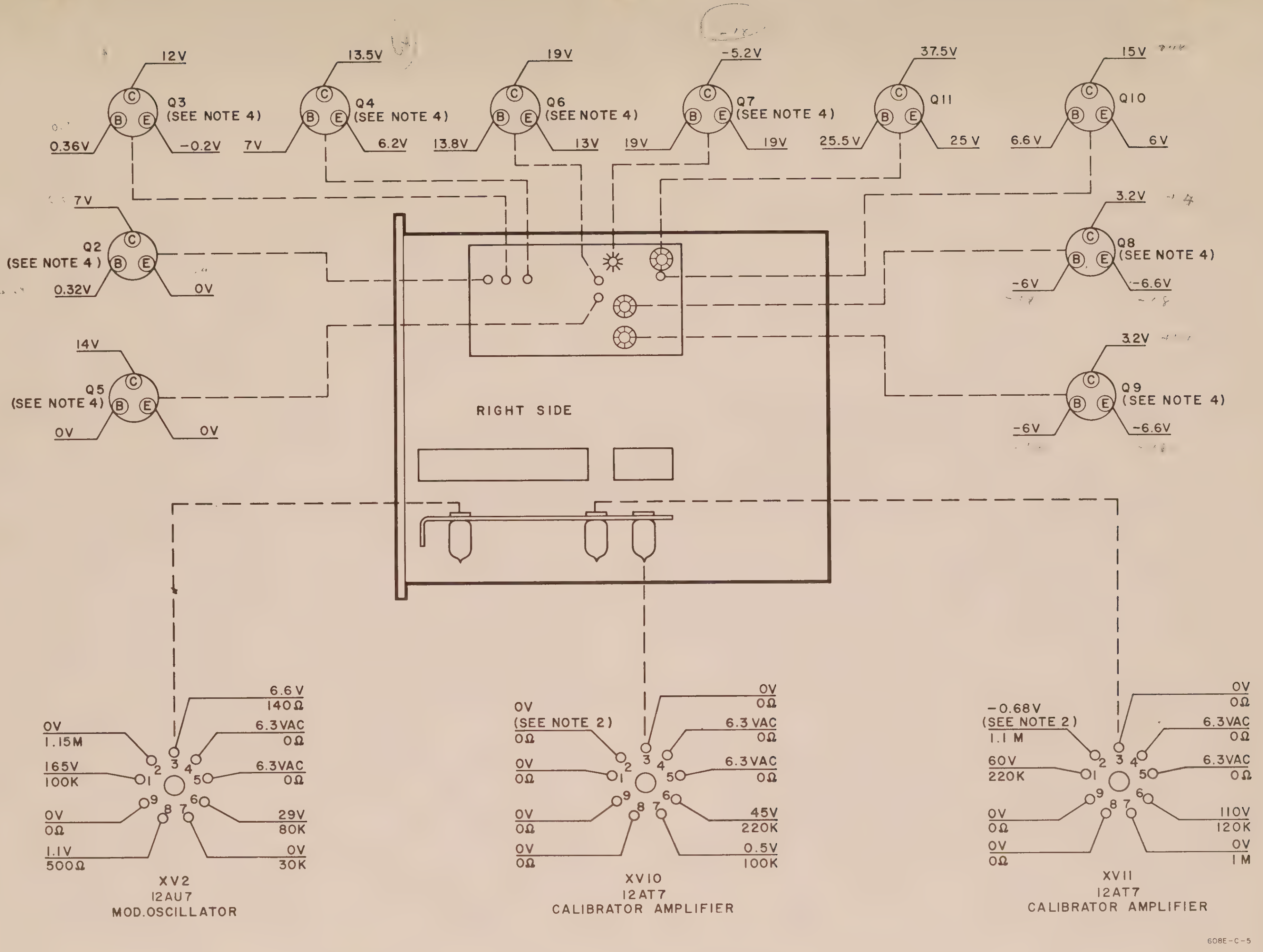


Figure 5-24. Voltage and Resistance Measurements (Sheet 1 of 3)

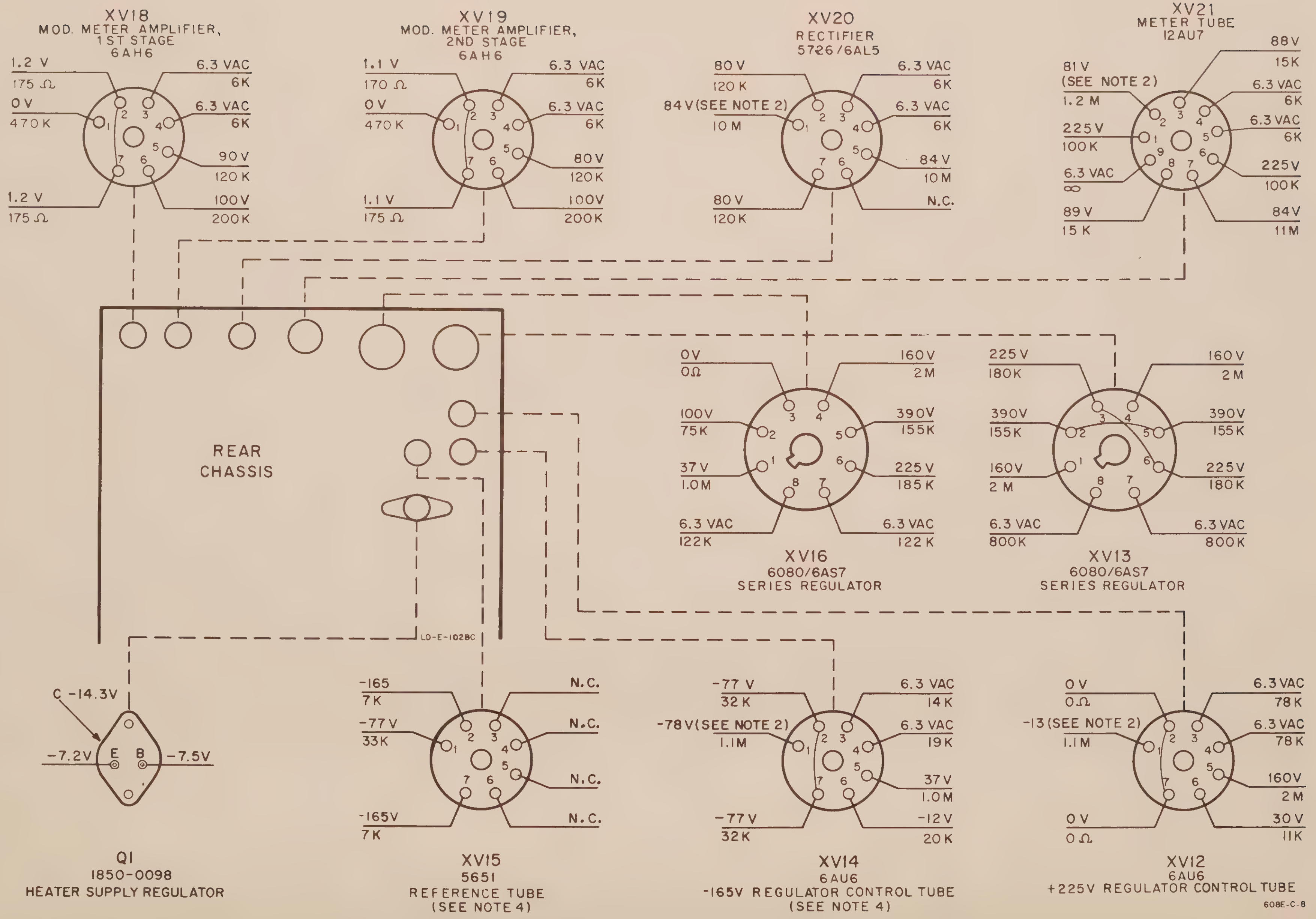
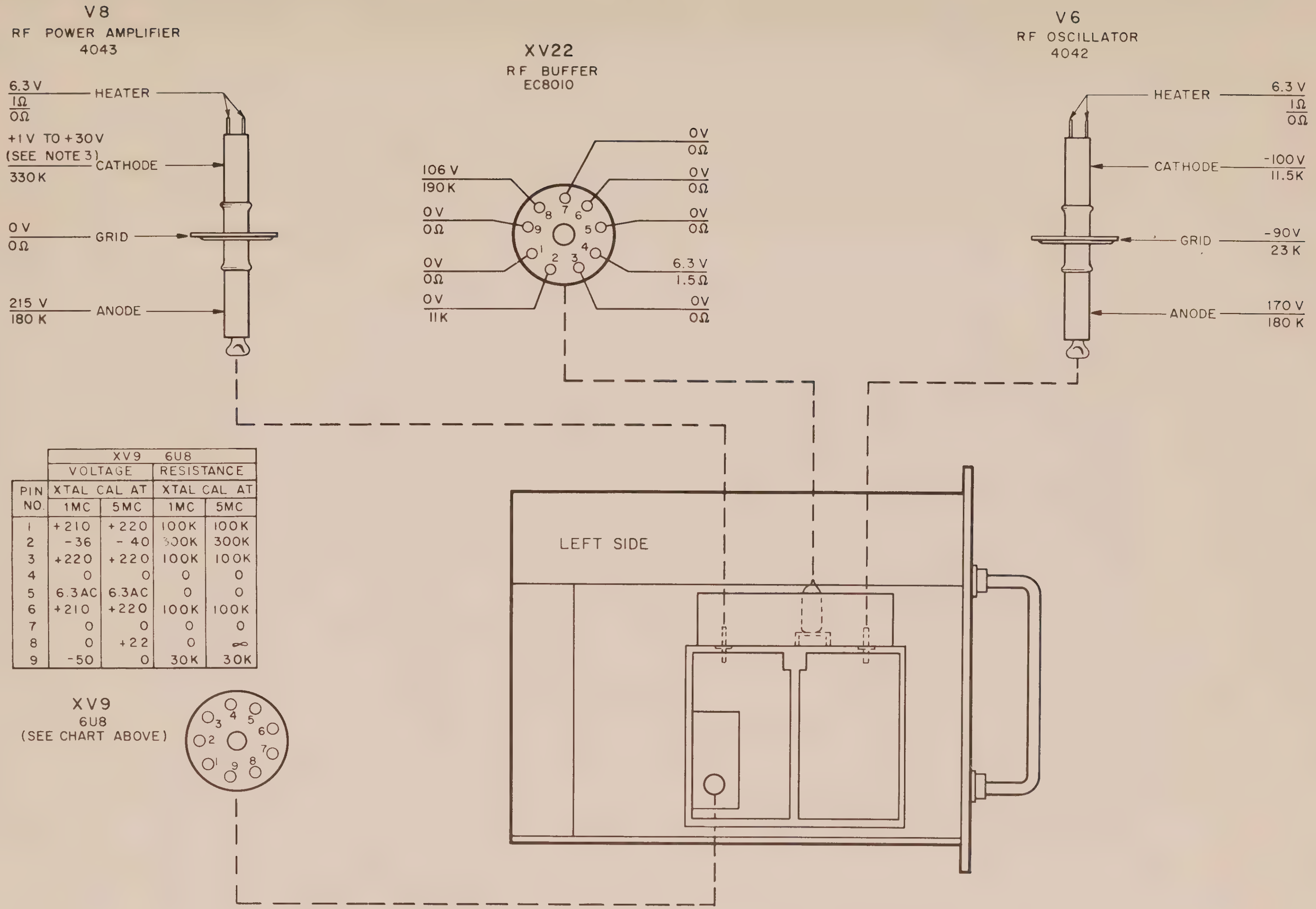
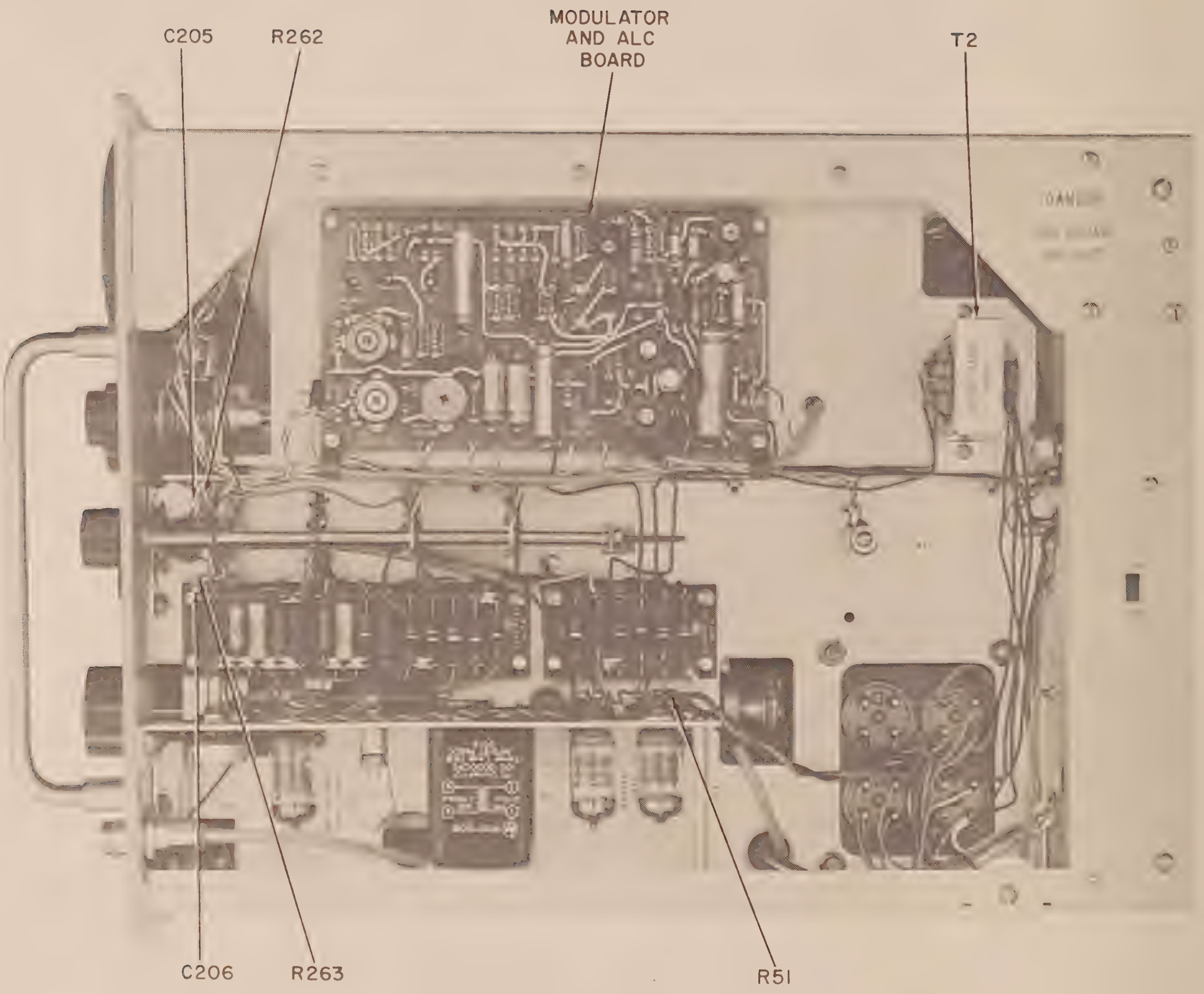


Figure 5-24. Voltage and Resistance Measurements (Sheet 2 of 3)



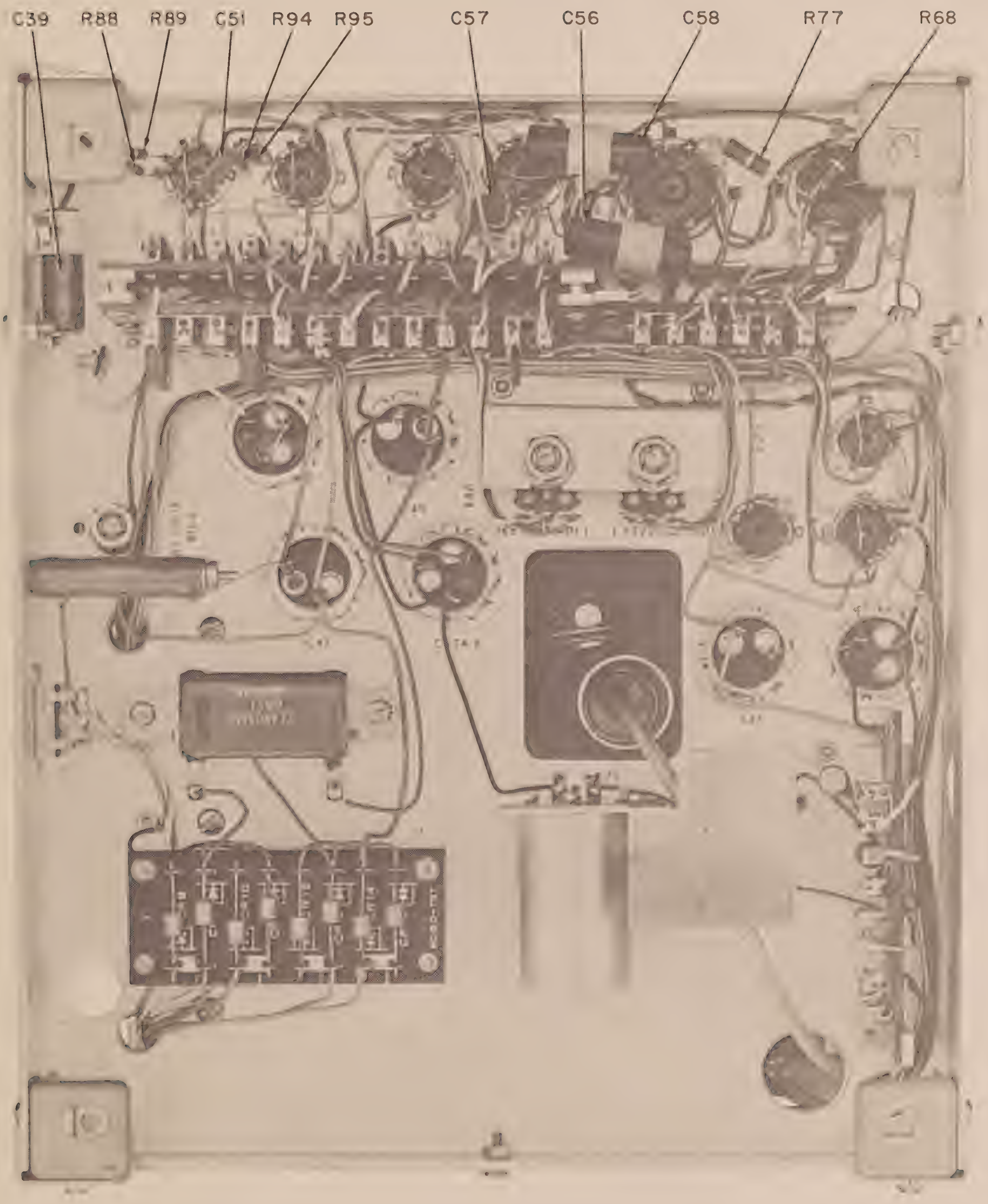
PIN NO.	XV9 6U8 VOLTAGE XTAL CAL AT 1MC	XV9 6U8 VOLTAGE XTAL CAL AT 5MC	XV9 6U8 RESISTANCE XTAL CAL AT 1MC	XV9 6U8 RESISTANCE XTAL CAL AT 5MC
1	+210	+220	100K	100K
2	-36	-40	300K	300K
3	+220	+220	100K	100K
4	0	0	0	0
5	6.3AC	6.3AC	0	0
6	+210	+220	100K	100K
7	0	0	0	0
8	0	+22	0	∞
9	-50	0	30K	30K

Figure 5-24. Voltage and Resistance Measurements (Sheet 3 of 3)



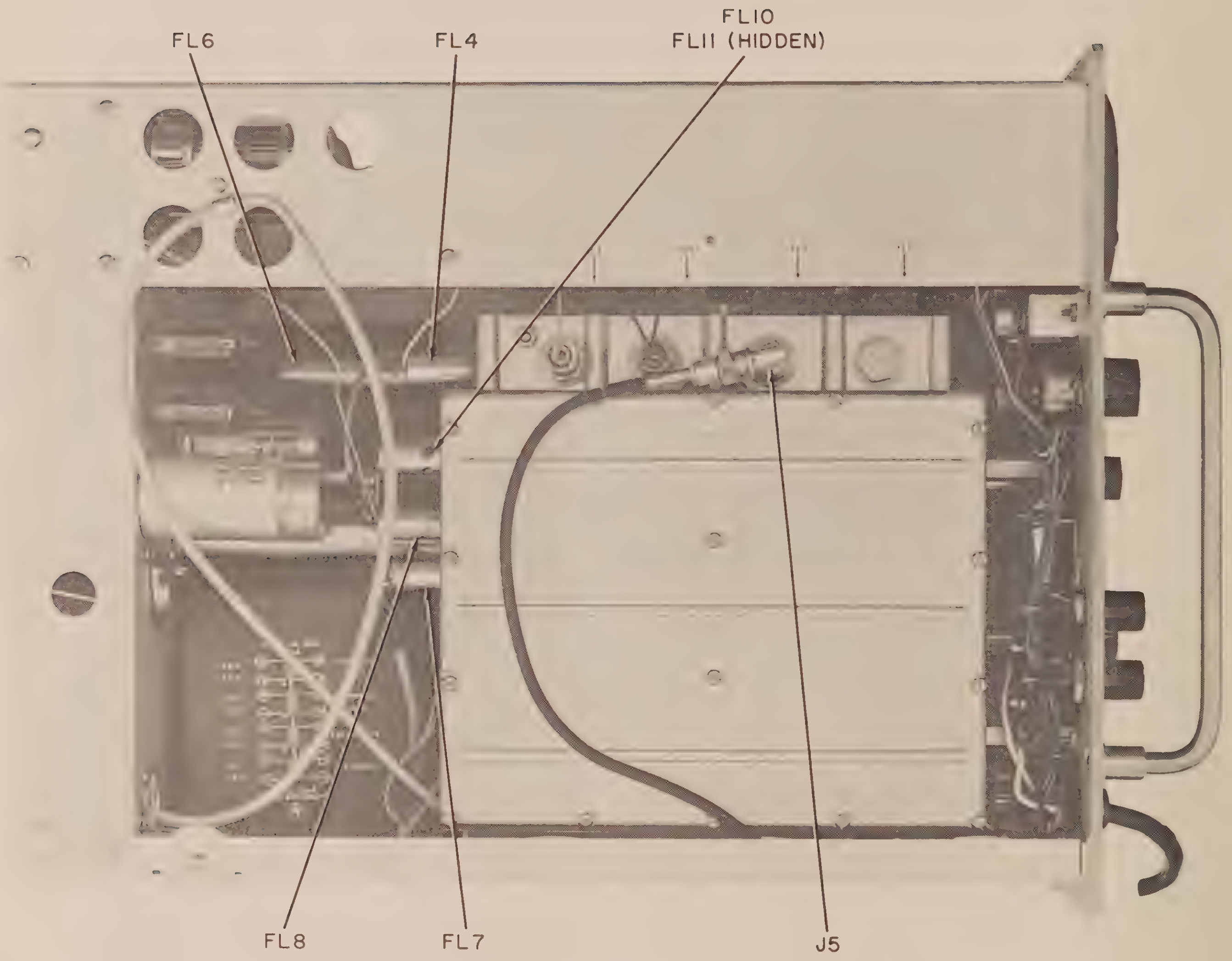
608E-A-14

Figure 5-25. Right Side View Showing Location of Unlabeled Chassis Components



608E-A-18

Figure 5-26. Rear View Showing Location of Unlabeled Chassis Components



608E-A-13

Figure 5-27. Left Side View Showing Location of Unlabeled Chassis Components

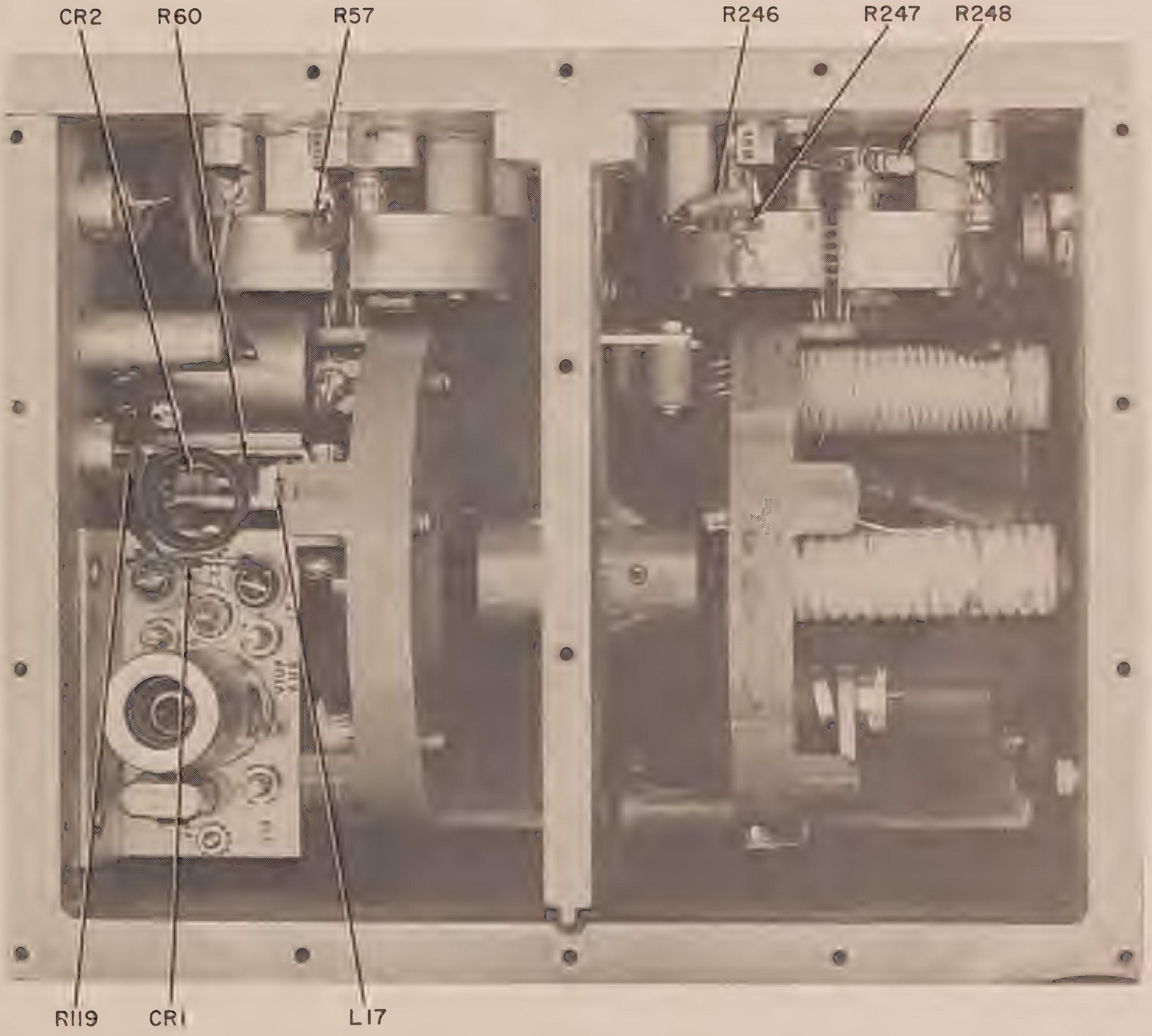
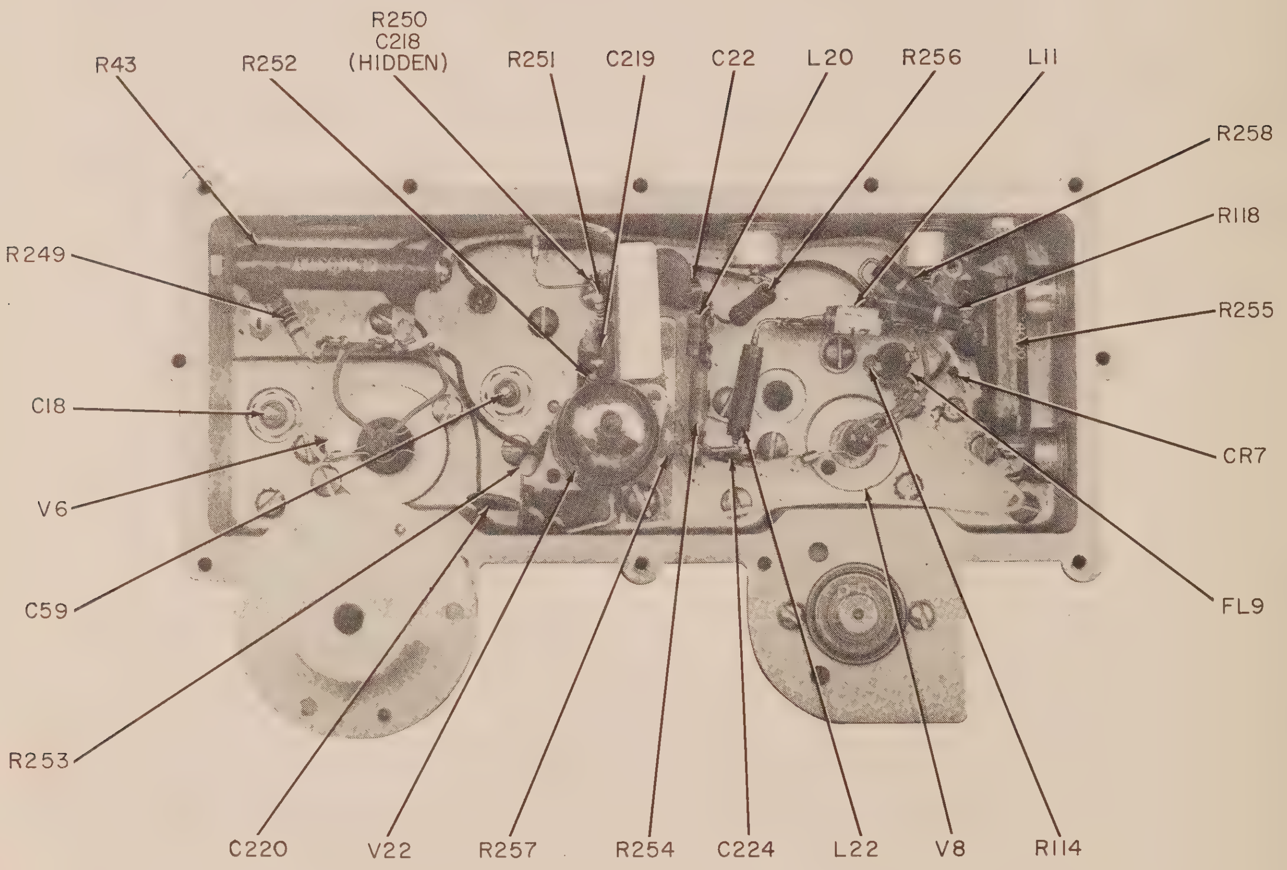


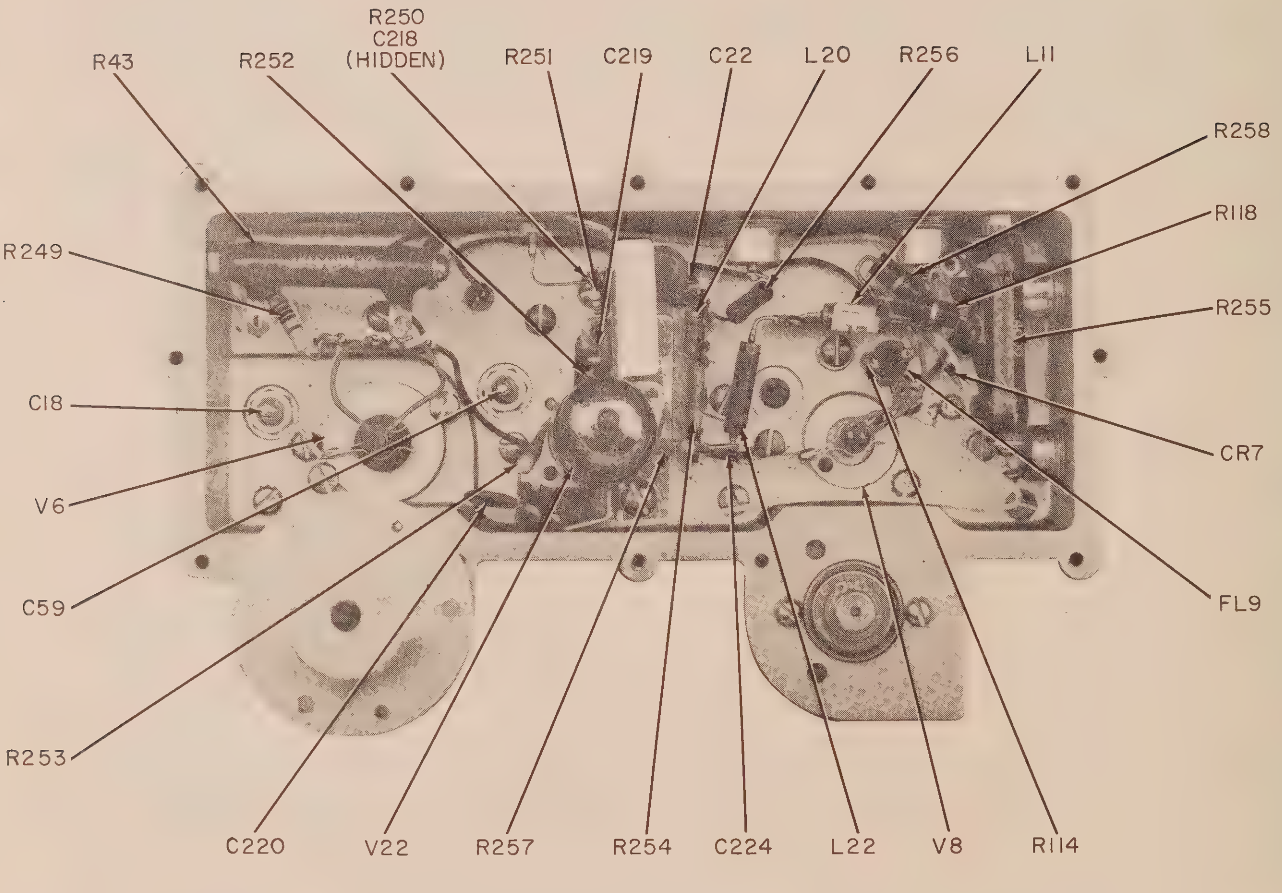
Figure 5-28. RF Generator Assembly, Side Cover Removed, Showing Location of Parts



608E-A-20

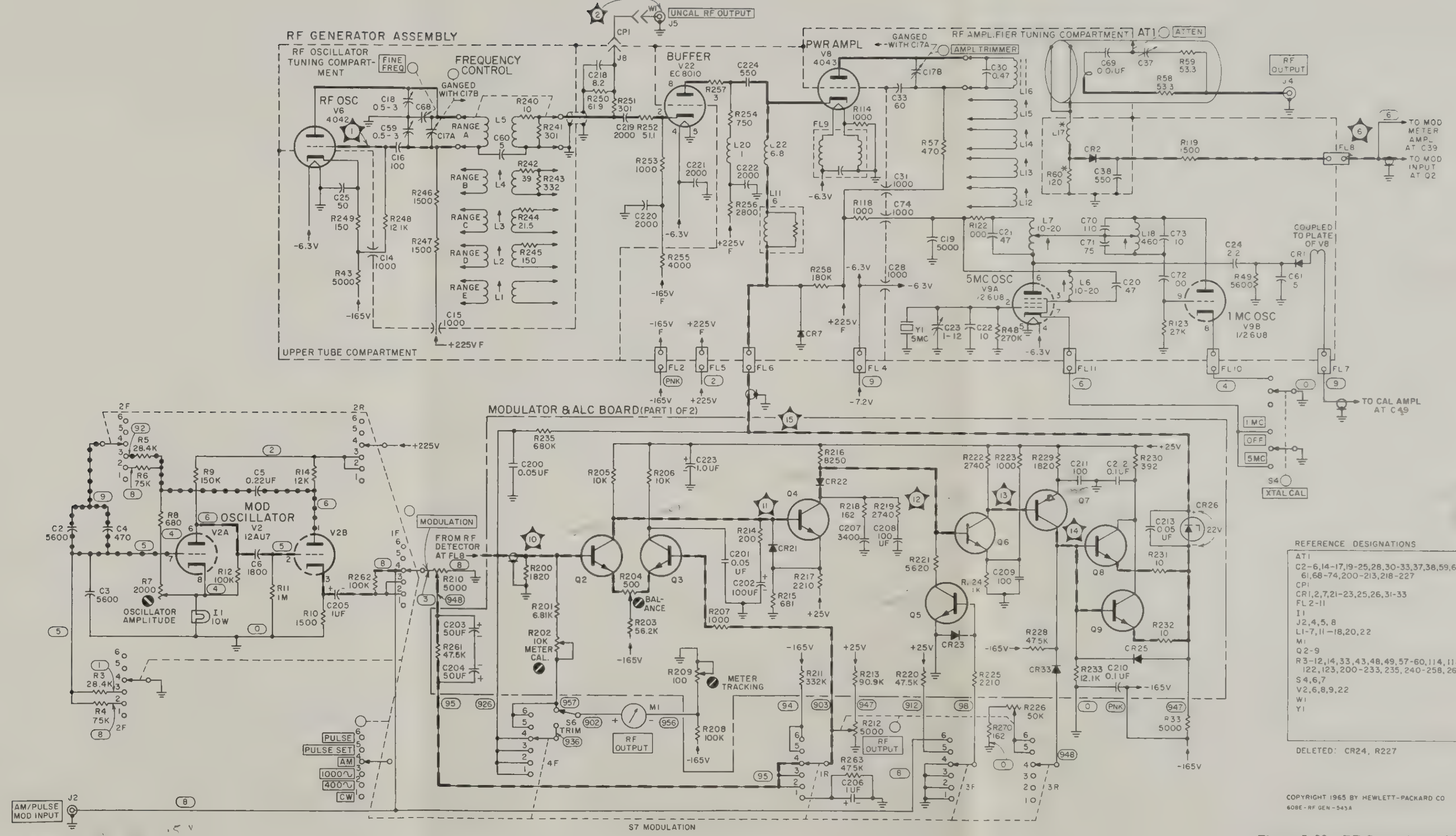
Figure 5-29. RF Generator Assembly, Top Cover Removed, Showing Location of Parts

Figure 5-30. RF Generator and Modulator Schematic Diagram



608E-A-20

Figure 5-29. RF Generator Assembly, Top Cover Removed, Showing Location of Parts



REFERENCE DESIGNATIONS

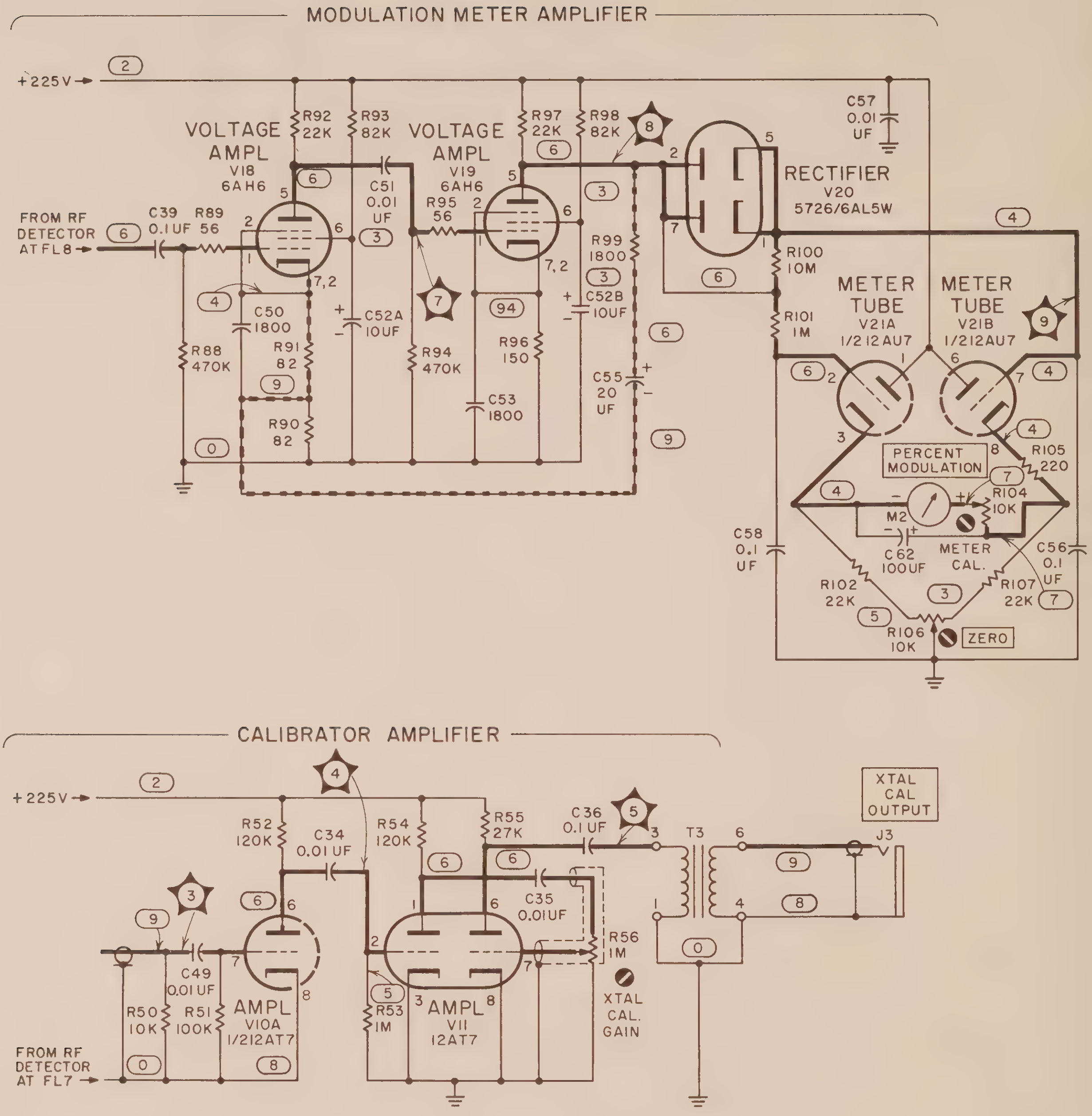
AT1
C2-6,14-17,19-25,28,30-33,37,38,59,60
61,68-74,200-213,218-227
CP1
CR1,2,7,21-23,25,26,31-33
FL2-11
I1
J2,4,5,8
L1-7,11-18,20,22
M1
Q2-9
R3-12,14,33,43,48,49,57-60,114,118,119
122,123,200-233,235,240-258,261-270
S4,6,7
V2,6,8,9,22
W1
Y1

DELETED: CR24, R227

COPYRIGHT 1965 BY HEWLETT-PACKARD CO
608E-RF GEN-543A

Figure 5-30. RF Generator and Modulator Sections Schematic Diagram

.5 v
1
.75
.75
8.0
8.0



REFERENCE DESIGNATIONS

C34-36, 39, 49-53, 55-58, 62
J3
M2
R50-56, 88-102, 104-107
T3
V10A, V11, V18-21

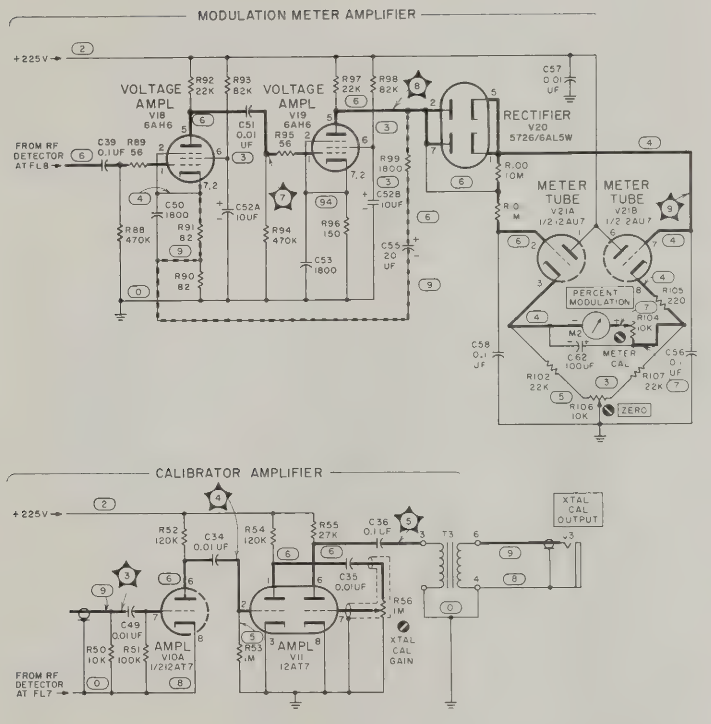
COPYRIGHT 1965 BY HEWLETT-PACKARD CO.

608E-CAL-543A

Figure 5-31. Modulation Meter and Crystal Calibration Sections Schematic Diagram

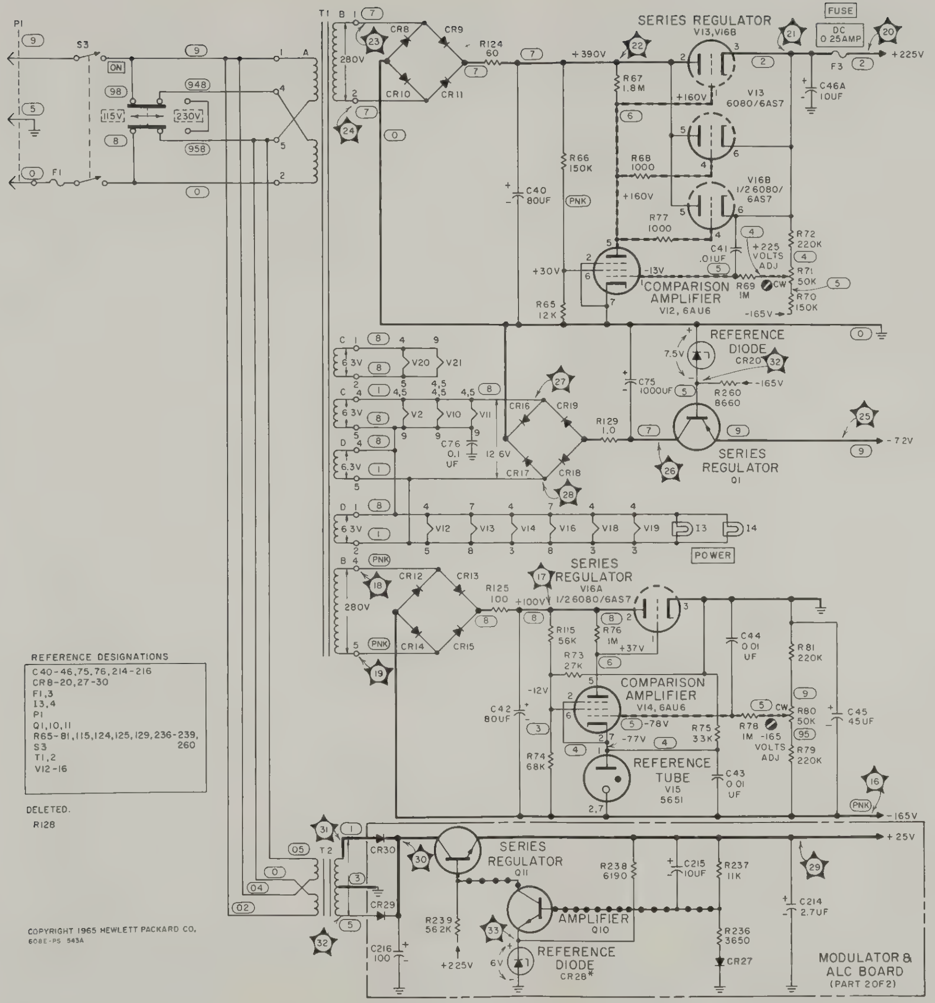
Figure 5-32. Power Supply
Schematic Diagram

Figure 5-30. RF Generator and Modulator Schematic Diagram



COPYRIGHT 1965 BY HEWLETT-PACKARD CO
608E-CAL-543A

Figure 5-31. Modulation Meter and Crystal Calibration Sections Schematic Diagram



REFERENCE DESIGNATIONS

C40-46,75,76,214-216
CR8-20,27-30
F1,3
I3,4
P1
Q1,10,11
R65-81,115,124,125,129,236-239, 260
S3
T1,2
V12-16

DELETED.
R128

COPYRIGHT 1965 HEWLETT PACKARD CO.
608E-PS 543A

Figure 5-32. Power Supply Schematic Diagram

SECTION VI

REPLACEABLE PARTS

6-1. INTRODUCTION.

6-2. This section contain information for ordering replacement parts. Table 6-1 lists parts in alpha-numerical order of their reference designations and indicates the description and hp stock number of each part, together with any applicable notes. Table 6-2 lists parts in alpha-numerical order of their hp stock numbers and provides the following information on each part:

a. Description of the part (see list of abbreviations below).

b. Typical manufacturer of the part in a five-digit code; see list of manufacturers (Table 6-3).

c. Manufacturer's stock number

d. Total quantity used in the instrument (TQ column).

6-3. ORDERING INFORMATION.

6-4. To order a replacement part, address order or inquiry to your local Hewlett-Packard sales and service office (see lists at rear of this manual).

6-5. Specify the following information for each part:

a. Model and complete serial number of instrument.

b. Hewlett-Packard stock number.

c. Circuit reference designation.

d. Complete description of parts.

REFERENCE DESIGNATORS

A = assembly
B = motor
BT = battery
C = capacitor
CP = coupler
CR = diode
DL = delay line
DS = device signaling (lamp)

E = misc electronic part
F = fuse
FL = filter
J = jack
K = relay
L = inductor
M = meter

MP = mechanical part
P = plug
Q = transistor
R = resistor
RT = thermistor
S = switch
T = transformer

TB = terminal board
TP = test point
V = vacuum, tube, neon bulb, photocell, etc.
W = cable
X = socket
Y = crystal

ABBREVIATIONS

A = amperes
A.F.C. = automatic frequency control
AMPL = amplifier

B.F.O. = beat frequency oscillator
BE CU = beryllium copper
BH = binder head
BP = bandpass
BRS = brass
BWO = backward wave oscillator

CCW = counter-clockwise
CER = ceramic
CMO = cabinet mount only
COEF = coefficient
COM = common
COMP = composition
CONN = connector
CP = cadmium plate
CRT = cathode-ray tube
CW = clockwise

DEPC = deposited carbon
DR = drive

ELECT = electrolytic
ENCAP = encapsulated
EXT = external

F = farads
FH = flat head
FIL H = fillister head
FXD = fixed

GE = germanium
GL = glass
GRD = ground(ed)

H = henries
HEX = hexagonal
HG = mercury
HR = hour(s)

IF = intermediate freq
IMPG = impregnated
INCD = incandescent
INCL = include(s)
INS = insulation(ed)
INT = internal

K = kilo = 1000

LIN = linear taper
LK WASH = lock washer
LOG = logarithmic taper
LPF = low pass filter

M = milli = 10^{-3}
MEG = meg = 10^{6}
MET FLM = metal film
MET OX = metallic oxide
MFR = manufacturer
MINAT = miniature
MOM = momentary
MTG = mounting
MY = "mylar"

N = nano (10^{-9})

N/C = normally closed
NE = neon
NI PL = nickel plate
N/O = normally open
NPO = negative positive zero (zero temperature coefficient)
NRFR = not recommended for field replacement
NSR = not separately replaceable

OBD = order by description
OH = oval head
OX = oxide

P = peak
PC = printed circuit
PF = picofarads = 10^{-12} farads
PH BRZ = phosphor bronze
PHL = Phillips
PIV = peak inverse voltage
P/O = part of
POLY = polystyrene
PORC = porcelain
POS = position(s)
POT = potentiometer
PP = peak-to-peak
PT = point
PWV = peak working voltage
RECT = rectifier
RF = radio frequency
RH = round head
RIV = reverse inverse voltage

RMO = rack mount only
RMS = root-mean square
RWV = reverse working voltage
S-B = slow-blow
SCR = screw
SE = selenium
SECT = section(s)
SEMICON = semiconductor
SI = silicon
SIL = silver
SL = slide
SPL = special
SST = stainless steel
SR = split ring
STL = steel

TA = tantalum
TD = time delay
TGL = toggle
TI = titanium
TOL = tolerance
TRIM = trimmer
TWT = traveling wave tube

U = micro = 10^{-6}

VAR = variable
VDCW = dc working volts

W/ = with
W = watts
WIV = working inverse voltage
WW = wirewound
W/O = without

01194-11

Figure 5-32. Power Supply
Schematic Diagram

SECTION VI

REPLACEABLE PARTS

6-1. INTRODUCTION.

6-2. This section contain information for ordering replacement parts. Table 6-1 lists parts in alpha-numerical order of their reference designations and indicates the description and hp stock number of each part, together with any applicable notes. Table 6-2 lists parts in alpha-numerical order of their hp stock numbers and provides the following information on each part:

a. Description of the part (see list of abbreviations below).

b. Typical manufacturer of the part in a five-digit code; see list of manufacturers (Table 6-3).

c. Manufacturer's stock number

d. Total quantity used in the instrument (TQ column).

6-3. ORDERING INFORMATION.

6-4. To order a replacement part, address order or inquiry to your local Hewlett-Packard sales and service office (see lists at rear of this manual).

6-5. Specify the following information for each part:

a. Model and complete serial number of instrument.

b. Hewlett-Packard stock number.

c. Circuit reference designation.

d. Complete description of parts.

REFERENCE DESIGNATORS

A = assembly
B = motor
BT = battery
C = capacitor
CP = coupler
CR = diode
DL = delay line
DS = device signaling (lamp)

E = misc electronic part
F = fuse
FL = filter
J = jack
K = relay
L = inductor
M = meter

MP = mechanical part
P = plug
Q = transistor
R = resistor
RT = thermistor
S = switch
T = transformer

TB = terminal board
TP = test point
V = vacuum, tube, neon bulb, photocell, etc.
W = cable
X = socket
Y = crystal

ABBREVIATIONS

A = amperes
A.F.C. = automatic frequency control
AMPL = amplifier

B.F.O. = beat frequency oscillator
BE CU = beryllium copper
BH = binder head
BP = bandpass
BRS = brass
BWO = backward wave oscillator

CCW = counter-clockwise
CER = ceramic
CMO = cabinet mount only
COEF = coefficient
COM = common
COMP = composition
CONN = connector
CP = cadmium plate
CRT = cathode-ray tube
CW = clockwise

DEPC = deposited carbon
DR = drive

ELECT = electrolytic
ENCAP = encapsulated
EXT = external

F = farads
FH = flat head
FIL H = fillister head
FXD = fixed

GE = germanium
GL = glass
GRD = ground(ed)

H = henries
HEX = hexagonal
HG = mercury
HR = hour(s)

IF = intermediate freq
IMPG = impregnated
INCD = incandescent
INCL = include(s)
INS = insulation(ed)
INT = internal

K = kilo = 1000

LIN = linear taper
LK WASH = lock washer
LOG = logarithmic taper
LPF = low pass filter

M = milli = 10^{-3}
MEG = meg = 10^{6}
MET FLM = metal film
MET OX = metallic oxide
MFR = manufacturer
MINAT = miniature
MOM = momentary
MTG = mounting
MY = "mylar"

N = nano (10^{-9})

N/C = normally closed
NE = neon
NI PL = nickel plate
N/O = normally open
NPO = negative positive zero (zero temperature coefficient)
NRFR = not recommended for field replacement
NSR = not separately replaceable

OBD = order by description
OH = oval head
OX = oxide

P = peak
PC = printed circuit
PF = picofarads = 10^{-12} farads
PH BRZ = phosphor bronze
PHL = Phillips
PIV = peak inverse voltage
P/O = part of
POLY = polystyrene
PORC = porcelain
POS = position(s)
POT = potentiometer
PP = peak-to-peak
PT = point
PWV = peak working voltage
RECT = rectifier
RF = radio frequency
RH = round head
RIV = reverse inverse voltage

RMO = rack mount only
RMS = root-mean square
RWV = reverse working voltage
S-B = slow-blow
SCR = screw
SE = selenium
SECT = section(s)
SEMICON = semiconductor
SI = silicon
SIL = silver
SL = slide
SPL = special
SST = stainless steel
SR = split ring
STL = steel

TA = tantalum
TD = time delay
TGL = toggle
TI = titanium
TOL = tolerance
TRIM = trimmer
TWT = traveling wave tube

U = micro = 10^{-6}

VAR = variable
VDCW = dc working volts

W/ = with
W = watts
WIV = working inverse voltage
WW = wirewound
W/O = without

01194-11

Table 6-1. Reference Designation Index

Reference Designation	ⓗ Stock No.	Description #	Note
AT1	00608-610	ATTENUATOR PLUNGER ASS'Y	
1	5040-0232	WINDOW:DIAL ATTENUATOR	
C2	0140-0071	C:FXD MICA 5600 PF 1% 500 VDCW	
C3	0140-0071	C:FXD MICA 5600 PF 1% 500 VDCW	
C4	0140-0085	C:FXD MICA 470 PF 5% 500 VDCW	
C5	0160-0018	C:FXD MY 0.22UF 10% 400VDCW	
C6	0140-0020	C:FXD MICA 1800 PF 10% 500 VDCW	
C7 THRU			
C13		NOT ASSIGNED	
C14	0150-0019	C:FXD CER 1000PF 20%	
C15	0150-0019	C:FXD CER 1000PF 20%	
C16	0150-0028	C:FXD CER 1CO PF 10% 500VDCW	
C17		THIS CAPACITOR IS NOT REPLACEABLE	
C17	608C-83C	WINDOW FREQ DIAL	
C18	0133-0001	C:VAR GLASS 0.5-3 PF	
C19	0150-0014	C:FXD CER 5000PF MIN 500VDCW	
C20	0150-0010	C:FXD CER 47PF 5% NPO 500VDCW	
C21	0150-0010	C:FXD CER 47PF 5% NPO 500VDCW	
C22	0150-0009	C:FXD CER 10PF +/-0.5PF NPO 500VDCW	
C23	0133-0002	C:VAR GLASS 1-12 PF	
C24	0150-0015	C:FXD TI 2.2PF 10% 500VDCW	
C25		NSR PART OF V6	
C26 THRU			
C27		NOT ASSIGNED	
C28	0150-0019	C:FXD CER 1000PF 20%	
C29		NOT ASSIGNED	
C30	0150-0021	C:FXD TI 0.47PF 5% 500VDCW	
C31	0150-0019	C:FXD CER 1000PF 20%	
C32		NOT ASSIGNED	
C33	608D-82	C:FXD MICA 60 UF 10% 600VDCW	
C34	0150-0012	C:FXD CER 0.01 UF 20% 1000VDCW	
C35	0150-0012	C:FXD CER 0.01 UF 20% 1000VDCW	
C36	0160-0013	C:FXD MY 0.1UF 10% 400VDCW	
C37		NSR PART OF ATTEN PROBE ASSY	
C38	0140-0069	C:FXD MICA 550 PF 10% 500 VDCW	
C39	0160-0013	C:FXD MY 0.1UF 10% 400VDCW	
C40	0180-0020	C:FXD ELECT 80UF -20/+100% 450VDCW	
C41	0150-0012	C:FXD CER C.01 UF 20% 1000VDCW	
C42	0180-0020	C:FXD ELECT 80UF -20/+100% 450VDCW	
C43	0150-0012	C:FXD CER 0.01 UF 20% 1000VDCW	
C44	0150-0012	C:FXD CER 0.01 UF 20% 1000VDCW	
C45	0180-0019	C:FXD ELECT 45UF -10/+50% 450VDCW	
C46	0180-0018	C:FXD ELECT 2X10UF 450VDCW	
C47 THRU			
C48		NOT ASSIGNED	
C49	0150-0012	C:FXD CER 0.01 UF 20% 1000VDCW	
C50	0140-0020	C:FXD MICA 1800 PF 10% 500 VDCW	

# See list of abbreviations in introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Reference Designation	ⓗ Stock No.	Description #	Note
C51	0150-0012	C:FXD CER 0.01 UF 20% 1000VDCW	
C52	0180-0018	C:FXD ELECT 2X10UF 450VDCW	
C53	0140-0020	C:FXD MICA 1800 PF 10% 500 VDCW	
C54		NOT ASSIGNED	
C55	0180-0018	C:FXD ELECT 2X10UF 450VDCW	
C56	0160-0013	C:FXD MY 0.1UF 10% 400VDCW	
C57	0150-0012	C:FXD CER 0.01 UF 20% 1000VDCW	
C58	0160-0013	C:FXD MY 0.1UF 10% 400VDCW	
C59	0133-0001	C:VAR GLASS 0.5-3 PF	
C60	0150-0008	C:FXD CER 5PF +/-0.5PF NPO 500VDCW	
C61	0150-0008	C:FXD CER 5PF +/-0.5PF NPO 500VDCW	
C62	0180-0094	C:FXD ELECT 100UF 25VDCW	
C63 THRU			
C67		NOT ASSIGNED	
C68	608D-59H	SPECIAL TRIMMER:FINE FREQ ADJUST	
C69	0170-0067	C:FXD MY 0.01UF 5% 50VDCW	
C70	0150-0006	C:FXD CER 110PF 2% NPO 500VDCW	
C71	0150-0038	C:FXD CER 75 PF NPO 500 VDCW	
C72	0150-0037	C:FXD CER 100 PF 1% NPO 500 VDCW	
C73	0150-0032	C:FXD CER 10PF +/- 1PF N750 500VDCW	
C74	0150-0019	C:FXD CER 1000PF 20%	
C75	0180-0057	C:FXD ELECT 1000UF 25VDCW	
C76	0150-0121	C:FXD CER 0.1UF +80%-20% 50VDCW	
C77 THRU			
C199		NOT ASSIGNED	
C200	0150-0096	C:FXD CER 0.05UF 100VDCW	
C201	0150-0096	C:FXD CER 0.05UF 100VDCW	
C202	0180-0094	C:FXD ELECT 100UF 25VDCW	
C203	0180-0105	C:FXD ELECT SEMI-POLARIZED 50UF 25VDCW	
C204	0180-0105	C:FXD ELECT SEMI-POLARIZED 50UF 25VDCW	
C205	0180-0119	C:FXD ELECT 1UF -10+100% 25VDCW	
C206	0180-0119	C:FXD ELECT 1UF -10+100% 25VDCW	
C207	0140-0160	C:FXD MICA 3400 PF 5% 500 VDCW	
C208	0180-0094	C:FXD ELECT 100UF 25VDCW	
C209	0140-0176	C:FXD MICA 100 PF 2% 300 VDCW	
C210	0160-0168	C:FXD MYLAR 0.1UF 10%	
C211	0140-0176	C:FXD MICA 100 PF 2% 300 VDCW	
C212	0160-0168	C:FXD MYLAR 0.1UF 10%	
C213	0150-0096	C:FXD CER 0.05UF 100VDCW	
C214	0180-0117	C:FXD ELECT TA 2.7UF 10% 35VDCW	
C215	0180-0059	C:FXD ELECT 10UF -10%+100% 25VDCW	
C216	0180-0138	C:FXD ELECT 100UF -10+100% 40VDCW	
C217		NOT ASSIGNED	
C218	0150-0045	C:FXD TI 8.2 PF 5% 500 VDCW	
C219	0150-0023	C:FXD CER 2000PF 20% 1000VDCW	
C220	0150-0023	C:FXD CER 2000PF 20% 1000VDCW	
C221	0150-0023	C:FXD CER 2000PF 20% 1000VDCW	
C222		DELETED	
C223	0180-0119	C:FXD ELECT 1UF -10+100% 25VDCW	
C224	0140-0069	C:FXD MICA 550 PF 10% 500 VDCW	
CP1	1250-0076	CONNECTOR:RF RIGHT ANGLE ADAPTER(UNCAL RF OUTPUT)	
CR1	1910-0011	SEMICON DEVICE:DIODE GERMANIUM	

See list of abbreviations in introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Reference Designation	hp Stock No.	Description #	Note
CR2	1900-0001	SEMICON DEVICE:DIODE SILICON 1N21B	
CR3 THRU			
CR6		NOT ASSIGNED	
CR7	1910-0002	SEMICON DEVICE DIODE GERMANIUM 1N38B	
CR8	1901-0009	RECTIFIER:MET 500V PIV 500MA	
CR9	1901-0009	RECTIFIER:MET 500V PIV 500MA	
CR10	1901-0009	RECTIFIER:MET 500V PIV 500MA	
CR11	1901-0009	RECTIFIER:MET 500V PIV 500MA	
CR12	1901-0007	RECTIFIER:MET 400V PIV 500MA	
CR13	1901-0007	RECTIFIER:MET 400V PIV 500MA	
CR14	1901-0007	RECTIFIER:MET 400V PIV 500MA	
CR15	1901-0007	RECTIFIER:MET 400V PIV 500MA	
CR16	1901-0026	DIODE:SILICON 200 PIV 0.5 AMP	
CR17	1901-0026	DIODE:SILICON 200 PIV 0.5 AMP	
CR18	1901-0026	DIODE:SILICON 200 PIV 0.5 AMP	
CR19	1901-0026	DIODE:SILICON 200 PIV 0.5 AMP	
CR20	1902-3129	DIODE:ZENER 7.5V	
CR21	1901-0025	DIODE,JUNCTION:5MA AT 1V 100 PIV	
CR22	1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	
CR23	1901-0025	DIODE,JUNCTION:5MA AT 1V 100 PIV	
CR24		DELETED	
CR25	1901-0025	DIODE,JUNCTION:5MA AT 1V 100 PIV	
CR26	1902-0227	DIODE,BREAKDOWN:22.6V 5% 1.5W	
CR27	1901-0025	DIODE,JUNCTION:5MA AT 1V 100 PIV	
CR28	1902-0049	DIODE,BREAKDOWN: 6.19V 5%	
CR29	1901-0026	DIODE:SILICON 200 PIV 0.5 AMP	
CR30	1901-0026	DIODE:SILICON 200 PIV 0.5 AMP	
F1	2110-0013	FUSE:CARTRIDGE 3.2 AMP 125V MAX SLOW BLOW FOR 115V OPERATION	
F1	2110-0005	FUSE:CARTRIDGE 1.6 AMP 250V FOR 230V OPERATION	
F2		NOT ASSIGNED	
F3	2110-0004	FUSE:CARTRIDGE 1/4 AMP 250V	
FL1		NOT ASSIGNED	
FL2	608A-27D	FILTER D GREEN	
FL3		NOT ASSIGNED	
FL4	608A-27A	FILTER A RED	
FL5	608A-27D	FILTER D GREEN	
FL6	608D-27C	FILTER RF (MOD) (BLUE)	
FL7	608A-27A	FILTER A RED	
FL8	608D-27B	FILTER RF (WHITE)	
FL9	608D-60M	CHOKE RF	
FL10	608A-27D	FILTER D GREEN	
FL11	608A-27D	FILTER D GREEN	
I1	2140-0007	LAMP:INCANDESCENT 250V 10W	
	1450-0013	SOCKET:CANDELABRA	
I2		NOT ASSIGNED	
I3	2140-0009	LAMP:INCANDESCENT 6-8V TYPE 47	
	1450-0019	LAMPHOLDER:MINIATURE BAYONET BASE	
	1450-0020	PILOT LIGHT:RED,JEWEL	
I4	2140-0009	LAMP:INCANDESCENT 6-8V TYPE 47	

# See list of abbreviations in introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Reference Designation	ⓗ Stock No.	Description #	Note
I4	1450-0009	LAMPHOLDER:MINIATURE BAYONET BASE	
J1		NOT ASSIGNED	
J2	1250-0001	CONNECTOR:BNC AM/PULSE MOD INPUT	
J3	1251-0071	CONNECTOR:JACK TELEPHONE-TYPE 2-CONTACT CRYSTAL OUTPUT	
J4	1250-0099	PANEL JACK BODY:TYPE N(RF OUTPUT)	
	1250-0144	CONNECTOR:RF CABLE JACK TYPE N	
J5		N S R PART OF W1	
	1250-0053	CAP:CONNECTOR BNC WITH CHAIN	
J6 AND			
J7		NOT ASSIGNED	
J8	1250-0118	CONNECTOR:BNC UNCAL RF OUTPUT (FL3 POSITION)	
L1	608D-60B	TURRET OSCILLATOR ASSY	
L2		NSR PART OF L1	
L3		NSR PART OF L1	
L4		NSR PART OF L1	
L5		NSR PART OF L1	
L6	9140-0008	COIL:VAR 10.5-20 UH	
L7	9140-0035	COIL:VAR CT 10.5 UH	
L8 THRU			
L9		NOT ASSIGNED	
L10		NOT ASSIGNED	
L11	608D-60K	CHOKE:RF	
L12	608D-60A	AMPLIFIER TURRET ASSY	
L13		NSR PART OF L12	
L14		NSR PART OF L12	
L15		NSR PART OF L12	
L16		NSR PART OF L12	
L17		NSR PART OF BOLOMETER ASSY	
L18	9140-0036	COIL:VAR CT 450-500 UH	
L20	9140-0096	COIL:FXD RF 1 UH	
L21		NOT ASSIGNED	
L22	9140-0026	COIL:FXD RF 6.8 UH	
M1	1120-0396	METER:OUTPUT	
M2	1120-0397	METER:MODULATION	
P1	8120-0015	POWER CABLE	
Q1	1850-0087	TRANSISTOR:GERMANIUM 2N1544 PNP ↔ RCA ≈ SK 3004	
Q2	1854-0071	TRANSISTOR:SILICON NPN 2N3391	
Q3	1854-0071	TRANSISTOR:SILICON NPN 2N3391	
Q4	1854-0071	TRANSISTOR:SILICON NPN 2N3391	
Q5	1854-0005	TRANSISTOR:2N708 NPN SILICON	
Q6	1854-0005	TRANSISTOR:2N708 NPN SILICON	
Q7	~~1850-0103~~	TRANSISTOR:2N2190	
	1205-0012	HEAT DISSIPATOR:SEMICONDUCTOR	
	NSW 1853-0080		

See list of abbreviations in introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Reference Designation	ⓗ Stock No.	Description #	Note
Q8	1854-0003	TRANSISTOR:NPN SILICON	
	1250-0011	NUT:COUPLING FOR TYPE N CONNECTOR	
Q9	1854-0003	TRANSISTOR:NPN SILICON	
	1250-0011	NUT:COUPLING FOR TYPE N CONNECTOR	
Q10	1854-0003	TRANSISTOR:NPN SILICON	
Q11	1854-~~0007~~ 0039	TRANSISTOR:5W 60V 1MC HFE 20	
	1250-0011	NUT:COUPLING FOR TYPE N CONNECTOR	
R1			
R2		NOT ASSIGNED	
R3	0727-0184	R:FXD DEPC 28.4 OHM 1% 1/2W	
R4	0730-0058	R:FXD DEPC 75K OHM 1% 1W	
R5	0727-0184	R:FXD DEPC 28.4 OHM 1% 1/2W	
R6	0730-0058	R:FXD DEPC 75K OHM 1% 1W	
R7	2100-0010	R:VAR COMP 2000 OHM 20% 1/4W	
R8	0690-6811	R:FXD COMP 680 OHM 10% 1W	
R9	0690-1541	R:FXD COMP 150K OHM 10% 1W	
R10	0690-1521	R:FXD COMP 1500 OHM 10% 1W	
R11	0690-1051	R:FXD COMP 1 MEGOHM 10% 1W	
R12	0690-1041	R:FXD COMP 100K OHM 10% 1W	
R13		NOT ASSIGNED	
R14	0693-1231	R:FXD COMP 12K OHM 10% 2W	
R15 THRU R32		NOT ASSIGNED	
R33	0819-0003	R:FXD WW 5000 OHM 10% 20W	
R34 THRU R42		NOT ASSIGNED	
R43	0816-0006	R:FXD WW 5000 OHM 10% 10W	
R44 THRU R47		NOT ASSIGNED	
R48	0687-2741	R:FXD COMP 270K OHM 10% 1/2W	
R49	0687-5621	R:FXD COMP 5600 OHM 10% 1/2W	
R50	0690-1031	R:FXD COMP 10K OHM 10% 1W	
R51	0687-1041	R:FXD COMP 100K OHM 10% 1/2W	
R52	0690-1241	R:FXD COMP 120K OHM 10% 1W	
R53	0690-1051	R:FXD COMP 1 MEGOHM 10% 1W	
R54	0690-1241	R:FXD COMP 120K OHM 10% 1W	
R55	0693-2731	R:FXD COMP 27K OHM 10% 2W	
R56	2100-0159	R:VAR COMP 1 MEGOHM 20% CW LOG 1/4W	
R57	0693-4711	R:FXD COMP 470 OHM 10% 2W	
R58	0721-0006	R:FXD DEPC 53.3 OHM 1% 1/8W	
R59	0721-0006	R:FXD DEPC 53.3 OHM 1% 1/8W	
R60	0684-1211	R:FXD COMP 120 OHM 10% 1/4W FACTORY SELECTED PART:TYPICAL VALUE GIVEN	
R61 THRU			
R64		NOT ASSIGNED	
R65	0690-1231	R:FXD COMP 12K OHM 10% 1W	
R66	0690-1541	R:FXD COMP 150K OHM 10% 1W	
R67	0690-1851	R:FXD COMP 1.8 MEGOHM 10% 1W	
R68	0690-1021	R:FXD COMP 1000 OHM 10% 1W	
R69	0690-1051	R:FXD COMP 1 MEGOHM 10% 1W	
R70	0690-1541	R:FXD COMP 150K OHM 10% 1W	
R71	2100-0157	R:VAR COMP 50K OHM 20% LIN 1/3W	
R72	0690-2241	R:FXD COMP 220K OHM 10% 1W	

# See list of abbreviations in introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Reference Designation	ⓗ Stock No.	Description #	Note
R73	0690-2731	R:FXD COMP 27K OHM 10% 1W	
R74	0693-6831	R:FXD COMP 68K OHM 10% 2W	
R75	0690-3331	R:FXD COMP 33K OHM 10% 1W	
R76	0690-1051	R:FXD COMP 1 MEGOHM 10% 1W	
R77	0690-1021	R:FXD COMP 1000 OHM 10% 1W	
R78	0690-1051	R:FXD COMP 1 MEGOHM 10% 1W	
R79	0690-2241	R:FXD COMP 220K OHM 10% 1W	
R80	2100-0157	R:VAR COMP 50K OHM 20% LIN 1/3W	
R81	0690-2241	R:FXD COMP 220K OHM 10% 1W	
R82 THRU			
R87		NOT ASSIGNED	
R88	0687-4741	R:FXD COMP 470K OHM 10% 1/2W	
R89	0687-5601	R:FXD COMP 56 OHM 10% 1/2W	
R90	0690-8201	R:FXD COMP 82 OHM 10% 1W	
R91	0690-8201	R:FXD COMP 82 OHM 10% 1W	
R92	0693-2231	R:FXD COMP 22K OHM 10% 2W	
R93	0690-8231	R:FXD COMP 82K OHM 10% 1W	
R94	0687-4741	R:FXD COMP 470K OHM 10% 1/2W	
R95	0687-5601	R:FXD COMP 56 OHM 10% 1/2W	
R96	0690-1511	R:FXD COMP 150 OHM 10% 1W	
R97	0693-2231	R:FXD COMP 22K OHM 10% 2W	
R98	0690-8231	R:FXD COMP 82K OHM 10% 1W	
R99	0690-1821	R:FXD COMP 1800 OHM 10% 1W	
R100	0690-1061	R:FXD COMP 10 MEGOHM 10% 1W	
R101	0690-1051	R:FXD COMP 1 MEGOHM 10% 1W	
R102	0693-2231	R:FXD COMP 22K OHM 10% 2W	
R103		NOT ASSIGNED	
R104	2100-0156	R:VAR COMP 10K OHM 20% 1/2W	
R105	0690-2211	R:FXD COMP 220 OHM 10% 1W	
R106	2100-0156	R:VAR COMP 10K OHM 20% 1/2W	
R107	0693-2231	R:FXD COMP 22K OHM 10% 2W	
R108 THRU			
R113		NOT ASSIGNED	
R114		NSR PART OF FL9	
R115	0690-5631	R:FXD COMP 56K OHM 10% 1W	
R116			
R117		NOT ASSIGNED	
R118	0690-1021	R:FXD COMP 1000 OHM 10% 1W	
R119	0690-1521	R:FXD COMP 1500 OHM 10% 1W	
R120			
R121		NOT ASSIGNED	
R122	0687-1021	R:FXD COMP 1000 OHM 10% 1/2W	
R123	0687-2731	R:FXD COMP 27K OHM 10% 1/2W	
R124	0818-0027	R:FXD WW 60 OHM 5% 40W	
R125	0819-0019	R:FXD WW 100 OHM 10% 20W	
R126 THRU			
R127		NOT ASSIGNED	
R128		DELETED	
R129	0813-0029	R:FXD WW 1 OHM 3% 3W	
R130 THRU			
R199		NOT ASSIGNED	
R200	0757-0429	R:FXD MET FLM 1.82K OHM 1% 1/8W	
R201	0757-0439	R:FXD MET FLM 6.81K OHM 1% 1/8W	
R202	2100-0092	R:VAR COMP 10K OHM 20% LIN 1/5W	
R203	0757-0854	R:FXD MET FLM 56.2K OHM 1% 1/2W	

See list of abbreviations in introduction to this section

Table 6-1 Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description #	Note
R204	2100-0151	R:VAR 500 OHM 20% 2/10W LIN	
R205	0757-0442	R:FXD MET FLM 10.0K OHM 1% 1/8W	
R206	0757-0442	R:FXD MET FLM 10.0K OHM 1% 1/8W	
R207	0757-0280	R:FXD MET FLM 1.00K OHM 1% 1/8W	
R208	0757-0465	R:FXD MET FLM 100K OHM 1% 1/8W	
R209	2100-0281	R:VAR WW 100 OHM 20% LIN 1-1/2W	
R210	2100-0235	R:VAR COMP 5K OHM 20% LIN 2.25W	
R211	0757-0477	R:FXD MET FLM 332K OHM 1% 1/8W	
R212	2100-1619	R:VAR COMP DUAL 5K-50K OHM 20% 10C LOG	
R213	0757-0464	R:FXD MET FLM 90.9K OHM 1% 1/8W	
R214	0757-0407	R:FXD MET FLM 200 OHM 1% 1/8W	
R215	0757-0419	R:FXD MET FLM 681 OHM 1% 1/8W	
R216	0757-0441	R:FXD MET FLM 8.25K OHM 1% 1/8W	
R217	0757-0430	R:FXD MET FLM 2.21K OHM 1% 1/8W	
R218	0757-0405	R:FXD MET FLM 162 OHM 1% 1/8W	
R219	0757-0281	R:FXD MET FLM 2.74K OHM 1% 1/8W	
R220	0757-0437	R:FXD MET FLM 4.75K OHM 1% 1/8W	
R221	0757-0200	R:FXD MET FLM 5.62K OHM 1% 1/8W	
R222	0757-0281	R:FXD MET FLM 2.74K OHM 1% 1/8W	
R223	0757-0280	R:FXD MET FLM 1.00K OHM 1% 1/8W	
R224	0757-0280	R:FXD MET FLM 1.00K OHM 1% 1/8W	
R225	0757-0430	R:FXD MET FLM 2.21K OHM 1% 1/8W	
R226	2100-1619	R:VAR COMP DUAL 5K-50K OHM 20% 10C LOG	
R227		DELETED	
R228	0757-0852	R:FXD MET FLM 47.5K OHM 1% 1/2W	
R229	0757-0429	R:FXD MET FLM 1.82K OHM 1% 1/8W	
R230	0757-0811	R:FXD MET FLM 392 OHM 1% 1/2W	
R231	0684-1001	R:FXD COMP 10 OHM 10% 1/4W	
R232	0684-1001	R:FXD COMP 10 OHM 10% 1/4W	
R233	0757-0444	R:FXD MET FLM 12.1K OHM 1% 1/8W	
R234	0819-0003	R:FXD WW 5000 OHM 10% 20W	
R235	0687-6841	R:FXD COMP 680K OHM 10% 1/2W	
R236	0757-0434	R:FXD MET FLM 3.65K OHM 1% 1/8W	
R237	0757-0443	R:FXD MET FLM 11.0K OHM 1% 1/8W	
R238	0757-0290	R:FXD MET FLM 6.19K OHM 1% 1/8W	
R239	0757-0854	R:FXD MET FLM 56.2K OHM 1% 1/2W	
R240	0757-0346	R:FXD MET FLM 10.0 OHM 1% 1/8W	
R241	0757-0410	R:FXD MET FLM 301 OHM 1% 1/8W	
R242	0698-3430	R2FXD MET FLM 21.5 OHM 1% 1/8W	
R243	0757-0411	R:FXD MET FLM 332 OHM 1% 1/8W	
R244	0684-3901	R:FXD COMP 39 OHM 10% 1/4W	
R245	0684-1511	R:FXD COMP 150 OHM 10% 1/4W	
R246	0757-0197	R:FXD MET FLM 1500 OHM 1% 1/2W	
R247	0757-0197	R:FXD MET FLM 1500 OHM 1% 1/2W	
R248	0757-0841	R:FXD MET FLM 12.1K OHM 1% 1/2W	
R249	0757-0801	R:FXD MET FLM 150 OHM 1% 1/2W	
R250	0757-0276	R:FXD MET FLM 61.9 OHM 1% 1/8W	
R251	0757-0410	R:FXD MET FLM 301 OHM 1% 1/8W	
R252	0757-0394	R:FXD MET FLM 51.1 OHM 1% 1/8W	
R253	0757-0159	R:FXD MET FLM 1000 OHM 1% 1/2W	
R254	0757-0817	R:FXD MET FLM 750 OHM 1% 1/2W	

# See list of abbreviations in introduction to this section

Table 6-1 Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description #	Note
R255	0816-0032	R:FXD WW 4K OHM 5% 10W	
R256	0812-0026	R:FXD WW 2800 OHM 5% 3W	
R257	0727-0002	R:FXD DEPC 3.0 OHM 1% 1/2W	
R258	0690-1841	R:FXD COMP 180K OHM 10% 1W	
R259		NOT ASSIGNED	
R260	0812-0038	R:FXD WW 8.66K OHM 3% 5W	
R261	0757-0457	R:FXD MET FLM 47.5K OHM 1% 1/8W	
R262	0757-0465	R:FXD MET FLM 100K OHM 1% 1/8W	
R263	0757-0457	R:FXD MET FLM 47.5K OHM 1% 1/8W	
S1			
S2		NOT ASSIGNED	
S3	3101-0003	SWITCH:TOGGLE DPST 3-AMP	
S4	3101-0012	SWITCH:TOG DPDT ON OFF ON	
S5		NOT ASSIGNED	
S6	3102-0006	SWITCH: SENSITIVE SPDT PIN PLUNGER	
S7	3100-0899	SWITCH:ROTARY	
T1	9100-0047	TRANSFORMER:POWER	
T2	9100-0342	TRANSFORMER:POWER	
T3	9120-0018	TRANSFORMER:AUDIO 15K : 600 OHM	
V1		NOT ASSIGNED	
V2	1932-0043	ELECTRON TUBE:12AU7 DUAL TRIODE	
	1200-0008	SOCKET:ELECTRON TUBE 9-PIN MINIATURE	
V3 THRU			
V5		NOT ASSIGNED	
V6	1921-0001	ELECTRON TUBE: UHF PENCIL TRIODE	
	608D-59A-3	SOCKET OSC TUBE	
	608D-59A-4	SOCKET OSC GRID	
	612A-38A	WRENCH TUBE	
	1200-0010	JACK:TYPE N	
V7		NOT ASSIGNED	
V8	1921-0002	ELECTRON TUBE: UHF PENCIL TRIODE	
	608D-58A	CONTACT AMP GRID	
	612A-38A	WRENCH TUBE	
	1200-0010	JACK:TYPE N	
V9	1933-0004	ELECTRON TUBE:6U8 OR 6U8A TRIODE PENTODE	
V10	1932-0027	ELECTRON TUBE:12AT7 DUAL TRIODE	
	1200-0008	SOCKET:ELECTRON TUBE 9-PIN MINIATURE	
V11	1932-0027	ELECTRON TUBE:12AT7 DUAL TRIODE	
	1200-0008	SOCKET:ELECTRON TUBE 9-PIN MINIATURE	
V12	1923-0021	ELECTRON TUBE: 6AU6 MIN PENTODE	
	1200-0009	SOCKET:TUBE 7-PIN MINAT	
V13	1932-0010	ELECTRON TUBE: 6080 DUAL TRIODE	
	1200-0005	SOCKET:TUBE	
V14	1923-0021	ELECTRON TUBE: 6AU6 MIN PENTODE	
	1200-0009	SOCKET:TUBE 7-PIN MINAT	
V15	1940-0001	ELECTRON TUBE:5651	
	1200-0009	SOCKET:TUBE 7-PIN MINAT	
V16	1932-0010	ELECTRON TUBE: 6080 DUAL TRIODE	
	1200-0005	SOCKET:TUBE	

See list of abbreviations in introduction to this section

Table 6-1. Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description #	Note
V17		NOT ASSIGNED	
V18	1923-0017	ELECTRON TUBE:6AH6 PENTODE	
	1200-0009	SOCKET:TUBE 7-PIN MINAT	
V19	1923-0017	ELECTRON TUBE:6AH6 PENTODE	
	1200-0009	SOCKET:TUBE 7-PIN MINAT	
V20	1930-0013	ELECTRON TUBE: 6AL5 TWIN DIODE	
	1200-0009	SOCKET:TUBE 7-PIN MINAT	
V21	1932-0043	ELECTRON TUBE:12AU7 DUAL TRIODE	
	1200-0008	SOCKET:ELECTRON TUBE 9-PIN MINIATURE	
V22	1921-0036	ELECTRON TUBE:UHF TRIODE 9-PIN BASE	
W1	00608-605	CABLE ASSY:UNCAL OUTPUT(FRONT PANEL)	
XY1	1200-0028	SOCKET-CRYSTAL	
Y1	0410-0009	CRYSTAL-QUARTZ 5 MC	
		MISCELLANEOUS	
	00608-603	TURRET ASSY:OSC	
	608C-60A	TURRET ASSY:AMP	
	0370-0025	KNOB:BLK 3/4 IN DIA 1/4 IN SHAFT	
	0370-0026	KNOB,BLK W/ARROW 3/4 IN. OD 1/8 IN. SHAFT	
	0370-0028	KNOB:BLK 1 IN. OD 1/4 IN. SHAFT	
	0370-0028	KNOB:BLK 1 IN. OD 1/4 IN. SHAFT	
	0370-0029	KNOB:BLK W/ARROW 1 IN. OD 1/4 IN. SHAFT	
	0370-0035	KNOB:BLK BAR W/ARROW 1 IN. OD 1/4IN. SHAFT	
	0370-0049	KNOB:SKIRTED BAR BLACK 1-IN DIA 3/8 SHAFT	
	0370-0050	HANDLE:CRANK ONLY 3/8 IN OD	
	608A-36F	SPRING LOADING EXTENSION 1/8 INCH OD	
	608D-42C	CRYSTAL CALIBRATOR ASSY	
	608D-44R	CABINET RACK	
	608D-44S	CABINET	
	608D-75T	RECTIFIER BOARD ASSY	
	00608-600	GENERATOR ASSY	
	00608-601	BOARD ASSEMBLY ALC	
	00608-602	BUFFER ASSY	
	00608-604	RESISTOR BOARD ASSY RECT	
	00608-606	CABLE HARNESS:POWER	
	00608-607	CABLE HARNESS:FRONT PANEL	
	00608-608	CABLE COUPLING	
	00608-611	CABLE LEVELLER INPUT	
	00608-612	CABLE LEVELLER OUTPUT	
	00608-613	RESISTOR BOARD ASSY	
	00608-614	RESISTOR BOARD ASSY	
	1410-0023	BEARING:BALL 7/8 IN OD X 9/32 WIDE	

# See list of abbreviations in introduction to this section

Table 6-2. Replaceable Parts (Cont'd)

ⓗⓟ Stock No.	Description#	Mfr.	Mfr. Part No.	TQ	
0133-0001	C:VAR GLASS 0.5-3 PF	28480	0133-0001	2	
0133-0002	C:VAR GLASS 1-12 PF	28480	0133-0002	1	
0140-0020	C:FXD MICA 1800 PF 10% 500 VDCW	00853	RCM30E182K	3	
0140-0069	C:FXD MICA 550 PF 10% 500 VDCW	00853	TYPE M 100 E10	2	
0140-0071	C:FXD MICA 5600 PF 1% 500 VDCW	14655	RCM30E562F	2	
0140-0085	C:FXD MICA 470 PF 5% 500 VDCW	00853	RCM20E471J	1	
0140-0160	C:FXD MICA 3400 PF 5% 500 VDCW	04062	RDM20F342J5S	1	
0140-0176	C:FXD MICA 100 PF 2% 300 VDCW	04062	RDM15F101G3C	2	
0150-0006	C:FXD CER 110PF 2% NPO 500VDCW	04222	SI-19	1	
0150-0008	C:FXD CER 5PF +/-0.5PF NPO 500VDCW	04222	CI-1	2	
0150-0009	C:FXD CER 10PF +/-0.5PF NPO 500VDCW	04222	TYPE CI-1	1	
0150-0010	C:FXD CER 47PF 5% NPO 500VDCW	04222	SI 47 PF 5% NPO	2	
0150-0012	C:FXD CER 0.01 UF 20% 1000VDCW	56289	29C214A3-H-1038	8	
0150-0014	C:FXD CER 5000PF MIN 500VDCW	04222	BCD-D1-4(5KPF)	1	
0150-0015	C:FXD TI 2.2PF 10% 500VDCW	78488	TYPE GA	1	
0150-0019	C:FXD CER 1000PF 20%	72982	327005X5U0102M	5	
0150-0021	C:FXD TI 0.47PF 5% 500VDCW	78488	TYPE GA	1	
0150-0023	C:FXD CER 2000PF 20% 1000VDCW	84411	TYPE 126	3	
0150-0028	C:FXD CER 100 PF 10% 500VDCW	56289	TYPE 501C18	1	
0150-0032	C:FXD CER 10PF +/- 1PF N750 500VDCW	72982	315-000-U2J0-100F	1	
0150-0037	C:FXD CER 100 PF 1% NPO 500 VDCW	72982	821-000-C0 G0-101F	1	
0150-0038	C:FXD CER 75 PF NPO 500 VDCW	72982	STYLE 307	1	
0150-0045	C:FXD TI 8.2 PF 5% 500 VDCW	78488	TYPE GA	1	
0150-0096	C:FXD CER 0.05UF 100VDCW	91418	-TA	3	
0150-0121	C:FXD CER 0.1UF +80%-20% 50VDCW	56289	5C50A	1	
0160-0013	C:FXD MY 0.1UF 10% 400VDCW	56289	160P10494	4	
0160-0018	C:FXD MY 0.22UF 10% 400VDCW	28480	0160-0018	1	
0160-0168	C:FXD MYLAR 0.1UF 10%	28480	0160-0168	2	
0170-0067	C:FXD MY 0.01UF 5% 50VDCW	84411	626C	1	
0180-0018	C:FXD ELECT 2X10UF 450VDCW	14655	KP 10196 1	3	
0180-0019	C:FXD ELECT 45UF -10/+50% 450VDCW	14655	CE41F450R	1	
0180-0020	C:FXD ELECT 80UF -20/+100% 450VDCW	14655	KP10202ISS0	2	
0180-0057	C:FXD ELECT 1000UF 25VDCW	56289	D32606	1	
0180-0059	C:FXD ELECT 10UF -10%+100% 25VDCW	56289	30D106G025BB4	1	
0180-0094	C:FXD ELECT 100UF 25VDCW	56289	30D107G025DH4	3	
0180-0105	C:FXD ELECT SEMI-POLARIZED 50UF 25VDCW	56289	D34114	2	
0180-0117	C:FXD ELECT TA 2.7UF 10% 35VDCW	56289	150D275X9035 B2	1	
0180-0119	C:FXD ELECT 1UF -10+100% 25VDCW	56289	30D105G025AA4	3	
0180-0138	C:FXD ELECT 100UF -10+100% 40VDCW	56289	D36254	1	
0370-0025	KNOB:BLK 3/4 IN DIA 1/4 IN SHAFT	28480	0370-0025	1	
0370-0026	KNOB:BLK W/ARROW 3/4 IN. OD 1/8 IN. SHAFT	28480	0370-0026	1	
0370-0028	KNOB:BLK 1 IN. OD 1/4 IN. SHAFT	28480	0370-0028	2	
0370-0029	KNOB:BLK W/ARROW 1 IN. OD 1/4 IN. SHAFT	28480	0370-0029	1	
0370-0035	KNOB:BLK BAR W/ARROW 1 IN. OD 1/4IN. SHAFT	28480	0370-0035	1	
0370-0049	KNOB:SKIRTED BAR BLACK 1-IN DIA 3/8 SHAFT	28480	0370-0049	1	
0370-0050	HANDLE:CRANK ONLY 3/8 IN OD	28480	0370-0050	1	
0410-0009	CRYSTAL-QUARTZ 5 MC	28480	0410-0009	1	
0684-1001	R:FXD COMP 10 OHM 10% 1/4W	01121	CB 1001	2	
0684-1211	R:FXD COMP 120 OHM 10% 1/4W	01121	CB 1211	1	
0684-1511	R:FXD COMP 150 OHM 10% 1/4W	01121	CB 1511	1	

See list of abbreviations in introduction to this section

Table 6-2. **Replaceable Parts** (Cont'd)

hp Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	
0684-3901	R:FXD COMP 39 OHM 10% 1/4W	01121	CB 3901	1	
0687-1021	R:FXD COMP 1000 OHM 10% 1/2W	01121	EB 1021	1	
0687-1041	R:FXD COMP 100K OHM 10% 1/2W	01121	EB 1041	1	
0687-2731	R:FXD COMP 27K OHM 10% 1/2W	01121	EB 2731	1	
0687-2741	R:FXD COMP 270K OHM 10% 1/2W	01121	EB 2741	1	
0687-4741	R:FXD COMP 470K OHM 10% 1/2W	01121	EB 4741	2	
0687-5601	R:FXD COMP 56 OHM 10% 1/2W	01121	EB 5601	2	
0687-5621	R:FXD COMP 5600 OHM 10% 1/2W	01121	EB 5621	1	
0687-6841	R:FXD COMP 680K OHM 10% 1/2W	01121	EB 6841	1	
0690-1021	R:FXD COMP 1000 OHM 10% 1W	01121	GB 1021	3	
0690-1031	R:FXD COMP 10K OHM 10% 1W	01121	GB 1031	1	
0690-1041	R:FXD COMP 100K OHM 10% 1W	01121	GB 1041	1	
0690-1051	R:FXD COMP 1 MEGOHM 10% 1W	01121	GB 1051	6	
0690-1061	R:FXD COMP 10 MEGOHM 10% 1W	01121	GB 1061	1	
0690-1231	R:FXD COMP 12K OHM 10% 1W	01121	GB 1231	1	
0690-1241	R:FXD COMP 120K OHM 10% 1W	01121	GB 1241	2	
0690-1511	R:FXD COMP 150 OHM 10% 1W	01121	GB 1511	1	
0690-1521	R:FXD COMP 1500 OHM 10% 1W	01121	GB 1521	2	
0690-1541	R:FXD COMP 150K OHM 10% 1W	01121	GB 1541	3	
0690-1821	R:FXD COMP 1800 OHM 10% 1W	01121	GB 1821	1	
0690-1841	R:FXD COMP 180K OHM 10% 1W	01121	GB 1841	1	
0690-1851	R:FXD COMP 1.8 MEGOHM 10% 1W	01121	GB 1851	1	
0690-2211	R:FXD COMP 220 OHM 10% 1W	01121	GB 2211	1	
0690-2241	R:FXD COMP 220K OHM 10% 1W	01121	GB 2241	3	
0690-2731	R:FXD COMP 27K OHM 10% 1W	01121	GB 2731	1	
0690-3331	R:FXD COMP 33K OHM 10% 1W	01121	GB 3331	1	
0690-5631	R:FXD COMP 56K OHM 10% 1W	01121	GB 5631	1	
0690-6811	R:FXD COMP 680 OHM 10% 1W	01121	GB 6811	1	
0690-8201	R:FXD COMP 82 OHM 10% 1W	01121	GB 8201	2	
0690-8231	R:FXD COMP 82K OHM 10% 1W	01121	GB 8231	2	
0693-1231	R:FXD COMP 12K OHM 10% 2W	01121	HB 1231	1	
0693-2231	R:FXD COMP 22K OHM 10% 2W	01121	HB 2231	4	
0693-2731	R:FXD COMP 27K OHM 10% 2W	01121	HB 2731	1	
0693-4711	R:FXD COMP 470 OHM 10% 2W	01121	HB 4711	1	
0693-6831	R:FXD COMP 68K OHM 10% 2W	01121	HB 6831	1	
0698-3430	R:FXD MET FLM 21.5 OHM 1% 1/8W	28480	0698-3430	1	
0721-0006	R:FXD DEPC 53.3 OHM 1% 1/8W	28480	0721-0006	2	
0727-0002	R:FXD DEPC 3.0 OHM 1% 1/2W	28480	0727-0002	1	
0727-0184	R:FXD DEPC 28.4 OHM 1% 1/2W	28480	0727-0184	2	
0730-0058	R:FXD DEPC 75K OHM 1% 1W	28480	0730-0058	2	
0757-0159	R:FXD MET FLM 1000 OHM 1% 1/2W	28480	0757-0159	1	
0757-0197	R:FXD MET FLM 1500 OHM 1% 1/2W	28480	0757-0197	2	
0757-0200	R:FXD MET FLM 5.62K OHM 1% 1/8W	28480	0757-0200	1	
0757-0276	R:FXD MET FLM 61.9 OHM 1% 1/8W	28480	0757-0276	1	
0757-0280	R:FXD MET FLM 1.00K OHM 1% 1/8W	28480	0757-0280	3	
0757-0281	R:FXD MET FLM 2.74K OHM 1% 1/8W	28480	0757-0281	2	
0757-0290	R:FXD MET FLM 6.19K OHM 1% 1/8W	28480	0757-0290	1	
0757-0346	R:FXD MET FLM 10.0 OHM 1% 1/8W	28480	0757-0346	1	
0757-0394	R:FXD MET FLM 51.1 OHM 1% 1/8W	28480	0757-0394	1	
0757-0405	R:FXD MET FLM 162 OHM 1% 1/8W	28480	0757-0405	1	

# See list of abbreviations in introduction to this section

Table 6-2. Replaceable Parts (Cont'd)

hp Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	
0757-0407	R:FXD MET FLM 200 OHM 1% 1/8W	28480	0757-0407	1	
0757-0410	R:FXD MET FLM 301 OHM 1% 1/8W	28480	0757-0410	2	
0757-0411	R:FXD MET FLM 332 OHM 1% 1/8W	28480	0757-0411	1	
0757-0419	R:FXD MET FLM 681 OHM 1% 1/8W	28480	0757-0419	1	
0757-0429	R:FXD MET FLM 1.82K OHM 1% 1/8W	28480	0757-0429	2	
0757-0430	R:FXD MET FLM 2.21K OHM 1% 1/8W	28480	0757-0430	2	
0757-0434	R:FXD MET FLM 3.65K OHM 1% 1/8W	28480	0757-0434	1	
0757-0437	R:FXD MET FLM 4.75K OHM 1% 1/8W	28480	0757-0437	1	
0757-0439	R:FXD MET FLM 6.81K OHM 1% 1/8W	28480	0757-0439	1	
0757-0441	R:FXD MET FLM 8.25K OHM 1% 1/8W	28480	0757-0441	1	
0757-0442	R:FXD MET FLM 10.0K OHM 1% 1/8W	28480	0757-0442	2	
0757-0443	R:FXD MET FLM 11.0K OHM 1% 1/8W	28480	0757-0443	1	
0757-0444	R:FXD MET FLM 12.1K OHM 1% 1/8W	28480	0757-0444	1	
0757-0457	R:FXD MET FLM 47.5K OHM 1% 1/8W	28480	0757-0457	2	
0757-0464	R:FXD MET FLM 90.9K OHM 1% 1/8W	28480	0757-0464	1	
0757-0465	R:FXD MET FLM 100K OHM 1% 1/8W	28480	0757-0465	2	
0757-0477	R:FXD MET FLM 332K OHM 1% 1/8W	28480	0757-0477	1	
0757-0801	R:FXD MET FLM 150 OHM 1% 1/2W	28480	0757-0802	1	
0757-0811	R:FXD MET FLM 392 OHM 1% 1/2W	28480	0757-0811	1	
0757-0817	R:FXD MET FLM 750 OHM 1% 1/2W	28480	0757-0817	1	
0757-0841	R:FXD MET FLM 12.1K OHM 1% 1/2W	28480	0757-0841	1	
0757-0852	R:FXD MET FLM 47.5K OHM 1% 1/2W	28480	0757-0852		
0757-0854	R:FXD MET FLM 56.2K OHM 1% 1/2W	28480	0757-0854		
0812-0026	R:FXD WW 2800 OHM 5% 3W	28480	0812-0026	1	
0812-0038	R:FXD WW 8.66K OHM 3% 5W	28480	0812-0038	1	
0813-0029	R:FXD WW 1 OHM 3% 3W	28480	0813-0029	1	
0816-0006	R:FXD WW 5000 OHM 10% 10W	28480	0816-0006	1	
0816-0032	R:FXD WW 4K OHM 5% 10W	28480	0816-0032	1	
0818-0027	R:FXD WW 60 OHM 5% 40W	28480	0818-0027	1	
0819-0003	R:FXD WW 5000 OHM 10% 20W	28480	0819-0003	1	
0819-0019	R:FXD WW 100 OHM 10% 20W	28480	0819-0019	1	
1120-0396	METER:OUTPUT	28480	1120-0396	1	
1120-0397	METER:MODULATION	28480	1120-0397	1	
1200-0005	SOCKET:TUBE	71785	101-29-11-032	2	
1200-0008	SOCKET:ELECTRON TUBE 9-PIN MINIATURE	71785	121-25-11-055	4	
1200-0009	SOCKET:TUBE 7-PIN MINAT	91662	04-703-05	6	
1200-0010	JACK:TYPE N	71785	131-52-12-016	2	
1200-0028	SOCKET-CRYSTAL	28480	1200-0028	1	
1205-0012	HEAT DISSIPATOR:SEMICONDUCTOR	28480	1205-0012	1	
1250-0001	CONNECTOR:BNC	91737	5126	1	
1250-0011	NUT:COUPLING FOR TYPE N CONNECTOR	28480	1250-0011		
1250-0053	CAP:CONNECTOR BNC WITH CHAIN	95712	366-6	1	
1250-0076	CONNECTOR:RF RIGHT-ANGLE ADAPTER	95712	4764-3	1	
1250-0099	PANEL JACK BODY:TYPE N(RF OUTPUT)	28480	1250-0099	1	
1250-0118	CONNECTOR:BNC	28480	1250-0118	1	
1250-0144	CONNECTOR:RF CABLE JACK TYPE N	28480	1250-0144	1	
1251-0071	CONNECTOR:JACK TELEPHONE-TYPE 2-CONTACT	82389	3J-1259	1	
1410-0023	BEARING:BALL 7/8 IN OD X 9/32 WIDE	21335	MS3KDD FS 58115	1	
1450-0009	LAMPHOLDER:MINIATURE BAYONET BASE	95263	708	2	
1450-0013	SOCKET:CANDELABRA	72765	659-1	1	
1850-0087	TRANSISTOR:GERMANIUM 2N1544 PNP	04713	2N1544	1	

# See list of abbreviations in introduction to this section

Table 6-2. Replaceable Parts (Cont'd)

ⓗⓟ Stock No.	Description #	Mfr.	Mfr. Part No.	TQ	
1850-0103	TRANSISTOR:2N2190	01295	2N2190	1	
1854-0003	TRANSISTOR:NPN SILICON	28480	1854-0003	3	
1854-0005	TRANSISTOR:2N708 NPN SILICON	07263	2N708	2	
1854-0007	TRANSISTOR:5W 60V 1MC HFE 20	02735	2N1700	1	
1854-0071	TRANSISTOR:SILICON NPN 2N3391	89473	16A792	3	
1900-0001	SEMICON DEVICE:DIODE SILICON 1N21B	96341	1N21B	1	
1901-0007	RECTIFIER:MET 400V PIV 500MA	81483	SD 500	4	
1901-0009	RECTIFIER:MET 500V PIV 500MA	81483	SD 95A	4	
1901-0025	DIODE,JUNCTION:5MA AT 1V 100 PIV	28480	1901-0025	4	
1901-0026	DIODE:SILICON 200 PIV 0.5 AMP	28480	1901-0026	6	
1902-0049	DIODE,BREAKDOWN: 6.19V 5%	28480	1902-0049	1	
1902-0227	DIODE,BREAKDOWN:22.6V 5% 1.5W	28480	1902-0227	1	
1902-3129	DIODE:ZENER 7.5V	28480	1902-3129	1	
1910-0002	SEMICON DEVICE DIODE GERMANIUM 1N38B	73293	1N38B	1	
1910-0011	SEMICON DEVICE:DIODE GERMANIUM	28480	1910-0011	1	
1910-0016	DIODE:GERMANIUM 100MA AT 0.85V 60PIV	28480	1910-0016	1	
1921-0001	ELECTRON TUBE: UHF PENCIL TROIDE	86684	4042	1	
1921-0002	ELECTRON TUBE: UHF PENCIL TRIODE	28480	1921-0002	1	
1921-0036	ELECTRON TUBE:UHF TRIODE 9-PIN BASE	95984	EC 8010	1	
1923-0017	ELECTRON TUBE:6AH6 PENTODE	33173	6AH6	2	
1923-0021	ELECTRON TUBE: 6AU6 MIN PENTODE	33173	6AU6	2	
1930-0013	ELECTRON TUBE: 6AL5 TWIN DIODE	33173	6AL5	1	
1932-0010	ELECTRON TUBE: 6080 DUAL TRIODE	86684	6080	2	
1932-0027	ELECTRON TUBE:12AT7 DUAL TRIODE	33173	12AT7	2	
1932-0043	ELECTRON TUBE:12AU7 DUAL TRIODE	73445	12AU7	2	
1933-0004	ELECTRON TUBE:6U8 OR 6U8A TRIODE PENTODE	33173	6U8	1	
1940-0001	ELECTRON TUBE:5651	86684	5651A	1	
2100-0010	R:VAR COMP 2000 OHM 20% 1/4W	28480	2100-0010	1	
2100-0092	R:VAR COMP 10K OHM 20% LIN 1/5W	28480	2100-0092	1	
2100-0151	R:VAR 500 OHM 20% 2/10W LIN	28480	2100-0151	1	
2100-0156	R:VAR COMP 10K OHM 20% 1/2W	28480	2100-0156	2	
2100-0157	R:VAR COMP 50K OHM 20% LIN 1/3W	28480	2100-0157	2	
2100-0159	R:VAR COMP 1 MEGOHM 20% CW LOG 1/4W	28480	2100-0159	1	
2100-0235	R:VAR COMP 5K OHM 20% LIN 2.25W	28480	2100-0235	1	
2100-0281	R:VAR WW 100 OHM 20% LIN 1-1/2W	28480	2100-0281	1	
2100-1619	R:VAR COMP DUAL 5K-50K OHM 20% 10C LOG	28480	2100-1619	2	
2110-0004	FUSE:CARTRIDGE 1/4 AMP 250V	75915	3AG/CAT. 312.250	1	
2110-0005	FUSE:CARTRIDGE 1.6 AMP 250V	71400	MDL 1.6	1	
2110-0013	FUSE:CARTRIDGE 3.2 AMP 125V MAX SLOW BLOW	75915	31303.2	1	
2140-0007	LAMP:INCANDESCENT 250V 10W	24455	8A/S6 12V	1	
2140-0009	LAMP:INCANDESCENT 6-8V TYPE 47	24455	47	2	
3100-0899	SWITCH:ROTARY	28480	3100-0899	1	
3101-0003	SWITCH:TOGGLE DPST 3-AMP	04009	81024-GB	1	
3101-0012	SWITCH:TOG DPDT ON OFF ON	04009	82609	1	
3102-0006	SWITCH: SENSITIVE SPDT PIN PLUNGER	91929	22SM261	1	
5040-0232	WINDOW:DIAL ATTENUATOR	28480	5040-0232	1	
8120-0015	POWER CABLE	70903	KH3981/PH70/7.5FT	1	
9100-0047	TRANSFORMER:POWER	98734	9100-0047	1	
9100-0342	TRANSFORMER:POWER	28480	9100-0342	1	

# See list of abbreviations in introduction to this section

Table 6-2. Replaceable Parts (Cont'd)

ⓗⓟ Stock No.	Description #	Mfr.	Mfr. Part No.	TQ
9120-0018	TRANSFORMER:AUDIO 15K : 600 OHM	28480	9120-0018	1
9140-0008	COIL:VAR 10.5-20 UH	98821	100C	1
9140-0026	COIL:FXD RF 6.8 UH	28480	9140-0026	1
9140-0035	COIL:VAR CT 10.5 UH	28480	9140-0035	1
9140-0036	COIL:VAR CT 450-500 UH	28480	9140-0036	1
9140-0096	COIL:FXD RF 1 UH	28480	9140-0096	1
00608-600	GENERATOR ASSY	28480	00608-600	1
00608-601	BOARD ASSEMBLY ALC	28480	00608-601	1
00608-602	BUFFER ASSY	28480	00608-602	1
00608-603	TURRET ASSY OSC	28480	00608-603	1
00608-604	RESISTOR BOARD ASSY RECT	28480	00608-604	1
00608-605	CABLE ASSY:UNCAL OUTPUT	28480	00608-605	1
00608-606	CABLE HARNESS:POWER	28480	00608-606	1
00608-607	CABLE HARNESS:FRONT PANEL	28480	00608-607	1
00608-608	CABLE COUPLING	28480	00608-608	1
00608-610	ATTENUATOR PLUNGER ASS'Y	28480	00608-610	1
00608-611	CABLE LEVELLER:INPUT	28480	00608-311	1
00608-612	CABLE LEVELLER:OUTPUT	28480	00608-612	1
00608-613	RESISTOR BOARD ASSY	28480	00608-613	1
00608-614	RESISTOR BOARD ASSY	28480	00608-614	1
608A-27A	FILTER A RED	28480	608A-27A	2
608A-27D	FILTER D GREEN	28480	608A-27D	4
608A-36F	SPRING LOADING EXTENSION 1/8 INCH OD	28480	608A-36F	1
608C-60A	TURRET ASSY., AMP	28480	608C-60A	1
608C-83C	WINDOW FREQ DIAL	28480	608C-83C	1
608D-27B	FILTER RF (WHITE)	28480	608D-27B	1
608D-27C	FILTER RF (MOD) (BLUE)	28480	608D-27C	1
608D-42C	CRYSTAL CALIBRATOR ASSY	28480	608D-42C	1
608D-44R	CABINET RACK	28480	608D-44R	1
608D-44S	CABINET	28480	608D-44S	1
608D-58A	CONTACT AMP GRID	28480	608D-58A	1
608D-59A-3	SOCKET OSC TUBE	28480	608D-59A-3	1
608D-59A-4	SOCKET OSC GRID	28480	608D-59A-4	1
608D-59H	SPECIAL TRIMMER:FINE FREQ ADJUST	28480	608D-59H	1
608D-60A	AMPLIFIER TURRET ASSY	28480	608D-60A	1
608D-60B	TURRET OSCILLATOR ASSY	28480	608D-60B	1
608D-60K	CHOKE-RF 6.8 UH	28480	608D-60K	1
608D-60M	CHOKE-RF	28480	608D-60M	1
608D-75T	RECTIFIER BOARD ASSY	28480	608D-75T	1
608D-82	C:FXD MICA 60 UF 10% 600VDCW	28480	608D-82	1
608D-7G5	STATOR OSC (GRID)	28480	608D-7G5	1
608D-7G6	STATOR AMP	28480	608D-7G6	1
608D-7R5	ROTOR OSC	28480	608D-7R5	1
608D-7R6	ROTOR AMP	28480	608D-7R6	1
612A-38A	WRENCH-TUBE	28480	612A-38A	2

See list of abbreviations in introduction to this section

TABLE 6-3.

CODE LIST OF MANUFACTURERS

The following code numbers are from the Federal Supply Code for Manufacturers Cataloging Handbooks H4-1 (Name to Code) and H4-2 (Code to Name) and their latest supplements. The date of revision and the date of the supplements used appear at the bottom of each page. Alphabetical codes have been arbitrarily assigned to suppliers not appearing in the H4 handbooks.

Code No.	Manufacturer	Address
00000	U.S.A. Common	Any supplier of U.S.
00136	McCoy Electronics	Mount Holly Springs, Pa.
00213	Sage Electronics Corp.	Rochester, N.Y.
00287	Cemco Inc.	Danielson, Conn.
00334	Humidial	Colton, Calif.
00373	Garlock Inc., Electronics Products Div.	Camden, N.J.
00656	Aerovox Corp.	New Bedford, Mass.
00779	Amp, Inc.	Harrisburg, Pa.
00781	Aircraft Radio Corp.	Boonton, N.J.
00815	Northern Engineering Laboratories, Inc.	Burlington, Wis.
00853	Sangamo Electric Co., Pickens Div.	Pickens, S.C.
00866	Goe Engineering Co.	Los Angeles, Calif.
00891	Carl E. Holmes Corp.	Los Angeles, Calif.
01121	Allen Bradley Co.	Milwaukee, Wis.
01255	Litton Industries, Inc.	Beverly Hills, Calif.
01281	TRW Semiconductors, Inc.	Lawndale, Calif.
01295	Texas Instruments, Inc., Transistor Products Div.	Dallas, Texas
01349	The Alliance Mfg. Co.	Alliance, Ohio
01589	Pacific Relays, Inc.	Van Nuys, Calif.
01930	Amerock Corp	Rockford, Ill.
01961	Pulse Engineering Co.	Santa Clara, Calif.
02114	Ferroxcube Corp. of America	Saugerties, N.Y.
02286	Cole Rubber and Plastics Inc.	Sunnyvale, Calif.
02660	Amphenol-Borg Electronics Corp.	Chicago, Ill.
02735	Radio Corp. of America, Semiconductor and Materials Div.	Somerville, N.J.
02771	Vocaline Co. of America, Inc.	Old Saybrook, Conn.
02777	Hopkins Engineering Co.	San Fernando, Calif.
03508	G.E. Semiconductor Prod. Dept.	Syracuse, N.Y.
03705	Apex Machine & Tool Co.	Dayton, Ohio
03797	Eldema Corp	Compton, Calif.
03877	Transitron Electric Corp.	Wakefield, Mass.
03888	Pyrofilm Resistor Co., Inc.	Cedar Knolls, N.J.
03954	Singer Co., Diehl Div. Finderne Plant	Sumerville, N.J.
04009	Arrow, Hart and Hegeman Elect. Co.	Hartford, Conn.
04013	Taurus Corp.	Lambertville, N.J.
04062	Elmenco Products Co.	New York, N.Y.
04222	Hi-Q Division of Aerovox	Myrtle Beach, S.C.
04354	Precision Paper Tube Co.	Chicago, Ill.
04404	Dymec Division of Hewlett-Packard Co.	Palo Alto, Calif.
04651	Sylvania Electric Products, Microwave Device Div.	Mountain View, Calif.
04713	Motorola, Inc., Semiconductor Prod. Div.	Phoenix, Arizona
04732	Fitron Co., Inc. Western Div.	Culver City, Calif.
04773	Automatic Electric Co.	Northlake, Ill.
04796	Sequoia Wire Co.	Redwood City, Calif.
04811	Precision Coil Spring Co.	El Monte, Calif.
04870	P.M. Motor Company	Westchester, Ill.
05006	Twentieth Century Plastics, Inc.	Los Angeles, Calif.
05277	Westinghouse Electric Corp. Semi-Conductor Dept.	Youngwood, Pa.
05347	Ultronix, Inc.	San Mateo, Calif.
05593	Illumitronic Engineering Co.	Sunnyvale, Calif.
05616	Cosmo Plastic (c o Electrical Spec. Co.)	Cleveland, Ohio
05624	Barber Colman Co.	Rockford, Ill.
05728	Tiffen Optical Co.	Roslyn Heights, Long Island, N.Y.
05729	Metro-Tel Corp.	Westbury, N.Y.
05783	Stewart Engineering Co.	Santa Cruz, Calif.
05820	Wakefield Engineering Inc.	Wakefield, Mass.
06004	Bassick Co., The	Bridgeport, Conn.
06175	Bausch and Lomb Optical Co.	Rochester, N.Y.
06402	E.T.A. Products Co. of America	Chicago, Ill.
06475	Western Devices Inc.	Burbank, Calif.
06540	Amatom Electronic Hardware Co., Inc.	New Rochelle, N.Y.
06555	Beede Electrical Instrument Co., Inc.	Penacook, N.H.
06666	General Devices Co., Inc.	Indianapolis, Ind.
06751	Nuclear Corp. of America U.S. Semcor Div.	Phoenix, Arizona
06812	Torrington Mfg. Co. West Div.	Van Nuys, Calif.
06980	Eitel-McCullough Inc.	San Carlos, Calif.
07088	Kelvin Electric Co.	Van Nuys, Calif.
07126	Digitran Co.	Pasadena, Calif.
07137	Transistor Electronics Corp.	Minneapolis, Minn.
07138	Westinghouse Electric Corp. Electronic Tube Div.	Elmira, N.Y.
07149	Filmohm Corp.	New York, N.Y.
07233	Cinch-Graphik Co.	City of Industry, Calif.
07261	Avnet Corp.	Los Angeles, Calif.
07263	Fairchild Camera & Inst. Corp. Semiconductor Div.	Mountain View, Calif.
07322	Minnesota Rubber Co.	Minneapolis, Minn.
07387	Birtcher Corp., The	Monterey Park, Calif.
07700	Technical Wire Products Inc.	Cranford, N.J.
07910	Continental Device Corp.	Hawthorne, Calif.
07933	Raytheon Mfg. Co., Semiconductor Div.	Mountain View, Calif.
07966	Shockley Semi-Conductor Laboratories	Palo Alto, Calif.
07980	Hewlett-Packard Co., Boonton Radio Div.	Rockaway, N.J.
08145	U.S. Engineering Co.	Los Angeles, Calif.
08289	Blinn, Delbert Co.	Pomona, Calif.
08358	Burgess Battery Co.	Niagara Falls, Ontario, Canada
08664	Bristol Co., The	Waterbury, Conn.
08717	Sloan Company	Sun Valley, Calif.
08718	ITT Cannon Electric Inc., Phoenix Div.	Phoenix, Arizona
08792	CBS Electronics Semiconductor Operations, Div of C.B.S. Inc.	Lowell, Mass.
08984	Mel-Rain	Indianapolis, Ind.
09026	Babcock Relays Div.	Costa Mesa, Calif.
09134	Texas Capacitor Co.	Houston, Texas
09145	Atohm Electronics	Sun Valley, Calif.
09250	Electro Assemblies, Inc.	Chicago, Ill.
09569	Mallory Battery Co. of Canada, Ltd.	Toronto, Ontario, Canada
10214	General Transistor Western Corp.	Los Angeles, Calif.
10411	Ti-Tal, Inc.	Berkeley, Calif.
10646	Carborundum Co.	Niagara Falls, N.Y.
11236	CTS of Berne, Inc.	Berne, Ind.
11237	Chicago Telephone of California, Inc.	So. Pasadena, Calif.
11242	Bay State Electronics Corp.	Waltham, Mass.
11312	Microwave Electronics Corp.	Palo Alto, Calif.
11534	Duncan Electronics Inc.	Costa Mesa, Calif.
11711	General Instrument Corp., Semiconductor Div., Products Group	Newark, N.J.
11717	Imperial Electronic, Inc.	Buena Park, Calif.
11870	Melabs, Inc.	Palo Alto, Calif.
12136	Philadelphia Handle Co.	Camden, N.J.
12697	Clarostat Mfg. Co.	Dover, N.H.
12859	Nippon Electric Co., Ltd.	Tokyo, Japan
12881	Metex Electronics Corp.	Clark, N.J.
12930	Delta Semiconductor Inc.	Newport Beach, Calif.
12954	Dickson Electronics Corp.	Scottsdale, Arizona
13103	Thermolloy	Dallas, Texas
13396	Telefunken (GmbH)	Hanover, Germany
13835	Midland-Wright Div. of Pacific Industries, Inc.	Kansas City, Kansas
14099	Sem-Tech	Newbury Park, Calif.
14193	Calif. Resistor Corp.	Santa Monica, Calif.
14298	American Components, Inc.	Conshohocken, Pa.
14433	ITT Semiconductor, A Div. of Int. Telephone & Telegraph Corp.	West Palm Beach, Fla.
14493	Hewlett-Packard Company	Loveland, Colo.
14655	Cornell Dublier Electric Corp.	Newark, N.J.
14674	Corning Glass Works	Corning, N.Y.
14752	Electro Cube Inc.	So. Pasadena, Calif.
14960	Williams Mfg. Co.	San Jose, Calif.
15203	Webster Electronics Co.	New York, N.Y.
15291	Adjustable Bushing Co.	N. Hollywood, Calif.
15558	Micron Electronics	Garden City, Long Island, N.Y.
15772	Twentieth Century Coil Spring Co.	Santa Clara, Calif.
15818	Amelco Inc.	Mt. View, Calif.
15909	Daven Div. Thomas A. Edison Ind. McGraw-Edison Co.	Long Island City, N.Y.
16037	Spruce Pine Mica Co.	Spruce Pine, N.C.
16179	Omni-Spectra Inc.	Detroit, Ill.
16352	Computer Diode Corp.	Lodi, N.J.
16688	Ideal Prec. Meter Co., Inc. De Jur Meter Div.	Brooklyn, N.Y.
16758	Delco Radio Div. of G.M. Corp.	Kokomo, Inc.
17109	Thermonetics Inc.	Canoga Park, Calif.
17474	Tranex Company	Mountain View, Calif.
18042	Power Design Pacific Inc.	Palo Alto, Calif.
18476	Ty-Car Mfg. Co., Inc.	Holliston, Mass.
18486	Radio Industries	Des Plaines, Ill.
18583	Curtis Instrument, Inc.	Mt. Kisco, N.Y.
18873	E.I. DuPont and Co., Inc.	Wilmington, Del.
18911	Durant Mfg. Co.	Milwaukee, Wis.
19315	Bendix Corp., The Eclipse-Poineer Div.	Teterboro, N.J.
19500	Thomas A. Edison Industries, Div. of McGraw-Edison Co.	West Orange, N.J.
19644	LRC Electronics	Horseheads, N.Y.
19701	Electra Mfg. Co.	Independence, Kansas
20183	General Atronics Corp.	Philadelphia, Pa.
21226	Executone, Inc.	New York, N.Y.
21335	Fafnir Bearing Co., The	New Britain, Conn.
21520	Fansteel Metallurgical Corp.	N. Chicago, Ill.
24455	G.E. Lamp Division	Nela Park, Cleveland, Ohio
24655	General Radio Co.	West Concord, Mass.
26365	Gries Reproducer Corp.	New Rochelle, N.Y.
26462	Grobet File Co. of America, Inc.	Carlstadt, N.J.
26992	Hamilton Watch Co.	Lancaster, Pa.
28480	Hewlett-Packard Co.	Palo Alto, Calif.
33173	G.E. Receiving Tube Dept.	Owensboro, Ky.
35434	Lectrohm Inc.	Chicago, Ill.
36196	Stanwyck Coil Products Ltd.	Hawkesbury, Ontario, Canada
37942	P.R. Mallory & Co. Inc.	Indianapolis, Ind.
39543	Mechanical Industries Prod. Co.	Akron, Ohio
40920	Miniature Precision Bearings, Inc.	Keene, N.H.
42190	Muter Co.	Chicago, Ill.
43990	C.A. Norgren Co.	Englewood, Colo.
44655	Ohmite Mfg. Co.	Skokie, Ill.
47904	Polaroid Corp.	Cambridge, Mass.
48620	Precision Thermometer & Inst. Co.	Southampton, Pa.
49956	Microwave & Power Tube Div.	Waltham, Mass.
52090	Rowan Controller Co.	Westminster, Md.
52983	Sanborn Company	Waltham, Mass.
54294	Shallcross Mfg. Co.	Selma, N.C.
55026	Simpson Electric Co.	Chicago, Ill.
55933	Sonotone Corp.	Elmsford, N.Y.
55938	Raytheon Co. Commercial Apparatus & Systems Div.	So. Norwalk, Conn.
56137	Spaulding Fibre Co., Inc.	Tonawanda, N.Y.
56289	Sprague Electric Co.	North Adams, Mass.
59446	Telex, Inc.	St. Paul, Minn.
59730	Thomas & Betts Co.	Elizabeth, N.J.
60741	Triplett Electrical Inst. Co.	Bluffton, Ohio
61775	Union Switch and Signal, Div. of Westinghouse Air Brake Co.	Pittsburgh, Pa.
62119	Universal Electric Co.	Owosso, Mich.
63743	Ward-Leonard Electric Co.	Mt. Vernon, N.Y.
64959	Western Electric Co., Inc.	New York, N.Y.
65092	Weston Inst. Inc. Weston-Newark	Newark, N.J.
66295	Wittek Mfg. Co.	Chicago, Ill.
66346	Revere Wollansak Div. Minn. Mining & Mft. Co.	St. Paul, Minn.
70276	Allen Mfg. Co.	Hartford, Conn.
70318	Allmetal Screw Product Co., Inc.	Garden City, N.Y.
70485	Atlantic India Rubber Works, Inc.	Chicago, Ill.
70563	Amperite Co., Inc.	Union City, N.J.
70903	Belden Mfg. Co.	Chicago, Ill.
70998	Bird Electronic Corp.	Cleveland, Ohio
71002	Birnbach Radio Co.	New York, N.Y.
71041	Boston Gear Works Div. of Murray Co. of Texas	Quincy, Mass.
71218	Bud Radio, Inc.	Willoughby, Ohio
71286	Camloc Fastener Corp.	Paramus, N.J.
71313	Cardwell Condenser Corp.	Lindenhurst L.I., N.Y.
71400	Bussmann Mfg. Div. of McGraw-Edison Co.	St. Louis, Mo.
71436	Chicago Condenser Corp.	Chicago, Ill.
71447	Calif. Spring Co., Inc.	Pico-Rivera, Calif.
71450	CTS Corp.	Elkhart, Ind.
71468	ITT Cannon Electric Inc.	Los Angeles, Calif.
71471	Cinema Plant, Hi-Q Div. Aerovox Corp.	Burbank, Calif.
71482	C.P. Clare & Co.	Chicago, Ill.
71590	Centralab Div. of Globe Union Inc.	Milwaukee, Wis.
71616	Commercial Plastics Co.	Chicago, Ill.
71700	Cornish Wire Co., The	New York, N.Y.
71707	Coto Coil Co., Inc.	Providence, R.I.
71744	Chicago Miniature Lamp Works	Chicago, Ill.
71753	A.O. Smith Corp., Crowley Div.	West Orange, N.J.
71785	Cinch Mfg. Co., Howard B. Jones Div.	Chicago, Ill.
71984	Dow Corning Corp.	Midland, Mich.
72136	Electro Motive Mfg. Co., Inc.	Willimantic, Conn.
72354	John E. Fast Co., Div. Victoreen Instr. Co.	Chicago, Ill.
72619	Dialight Corp.	Brooklyn, N.Y.
72656	Indiana General Corp., Electronics Div.	Keasby, N.J.
72765	Drake Mfg. Co.	Chicago, Ill.
72825	Hugh H. Eby Inc.	Philadelphia, Pa.
72928	Gudeman Co.	Chicago, Ill.
72964	Robert M. Hadley Co.	Los Angeles, Calif.
72982	Erie Technological Products, Inc.	Erie, Pa.
73061	Hansen Mfg. Co., Inc.	Princeton, Ind.
73076	H.M. Harper Co.	Chicago, Ill.
73138	Helipot Div. of Beckman Inst., Inc.	Fullerton, Calif.
73293	Hughes Products Division of Hughes Aircraft Co.	Newport Beach, Calif.
73445	Amperex Electronic Co., Div. of North American Phillips Co., Inc.	Hicksville, N.Y.
73506	Bradley Semiconductor Corp.	New Haven, Conn.
73559	Carling Electric, Inc.	Hartford, Conn.
73682	George K. Garrett Co., Div. MSL Industries Inc.	Philadelphia, Pa.
73734	Federal Screw Products Inc.	Chicago, Ill.
73743	Fischer Special Mfg. Co.	Cincinnati, Ohio
73793	General Industries Co., The	Elyria, Ohio
73846	Goshen Stamping & Tool Co.	Goshen, Ind.
73899	JFD Electronics Corp.	Brooklyn, N.Y.
73905	Jennings Radio Mfg. Corp.	San Jose, Calif.
74276	Signalite Inc.	Neptune, N.J.
74455	J.H. Winns, and Sons	Winchester, Mass.
74861	Industrial Condenser Corp.	Chicago, Ill.
74868	R.F. Products Division of Amphenol-Borg Electronics Corp.	Danbury, Conn.
74970	E.F. Johnson Co.	Waseca, Minn.
75042	International Resistance Co.	Philadelphia, Pa.
75378	James Knights Co.	Sandwich, Ill.
75382	Kulka Electric Corporation	Mt. Vernon, N.Y.
75818	Lenz Electric Mfg. Co.	Chicago, Ill.
75915	Littlefuse, Inc.	Des Plaines, Ill.
76005	Lord Mfg. Co.	Erie, Pa.
76210	C.W. Marwedel	San Francisco, Calif.
76433	General Instrument Corp., Micamold Div.	Newark, N.J.
76487	James Millen Mfg. Co., Inc.	Malden, Mass.
76493	J.W. Miller Co.	Los Angeles, Calif.
76530	Monadnock Mills	San Leandro, Calif.
76545	Mueller Electric Co.	Cleveland, Ohio
76854	Oak Manufacturing Co.	Crystal Lake, Ill.
77068	Bendix Corp., The Bendix Pacific Div.	N. Hollywood, Calif.
77075	Pacific Metals Co.	San Francisco, Calif.
77221	Phanostran Instrument and Electronic Co.	South Pasadena, Calif.
77252	Philadelphia Steel and Wire Corp.	Philadelphia, Pa.
77342	American Machine & Foundry Co. Potter & Brumfield Div.	Princeton, Ind.
77630	TRW Electronic Components Div.	Camden, N.J.
77638	General Instrument Corp., Rectifier Div.	Brooklyn, N.Y.
77764	Resistance Products Co.	Harrisburg, Pa.
77969	Rubbercraft Corp. of Calif.	Torrance, Calif.
78189	Shakeproof Division of Illinois Tool Works	Elgin, Ill.
78283	Signal Indicator Corp.	New York, N.Y.
78290	Struthers-Dunn Inc.	Pitman, N.J.
78452	Thompson-Bremer & Co.	Chicago, Ill.
78471	Tilley Mfg. Co.	San Francisco, Calif.
78488	Stackpole Carbon Co.	St. Marys, Pa.
78493	Standard Thomson Corp.	Waltham, Mass.
78553	Tinnerman Products, Inc.	Cleveland, Ohio
78790	Transformer Engineers	San Gabriel, Calif.
78947	Ucinite Co.	Newtonville, Mass.
79136	Waldes Kohinoor Inc.	Long Island City, N.Y.
79142	Veeder Root, Inc.	Hartford, Conn.
79251	Wenco Mfg. Co.	Chicago, Ill.
79727	Continental-Wirt Electronics Corp.	Philadelphia, Pa.
79963	Zierick Mfg. Corp.	New Rochelle, N.Y.

00015-41
Revised November, 1965

From: FSC. Handbook Supplements
H4-1 Dated JULY 1965
H4-2 Dated NOV 1962

TABLE 6-3.

CODE LIST OF MANUFACTURERS (Continued)

Code No.	Manufacturer	Address
80031	Mepco Division of Sessions Clock Co.	Morristown, N.J.
80120	Schnitzer Alloy Products Co.	Elizabeth, N.J.
80130	Times Telephoto Equipment	New York, N.Y.
80131	Electronic Industries Association. Any brand Tube meeting EIA Standards-Washington, DC	
80207	Unimax Switch, Div. Maxon Electronics Corp.	Wallingford, Conn.
80223	United Transformer Corp.	New York, N.Y.
80248	Oxford Electric Corp.	Chicago, Ill.
80294	Bourns Inc.	Riverside, Calif.
80411	Acro Div. of Robertshaw Controls Co.	Columbus, Ohio
80486	All Star Products Inc.	Defiance, Ohio
80509	Avery Adhesive Label Corp.	Monrovia, Calif.
80583	Hammarlund Co., Inc.	New York, N.Y.
80640	Stevens, Arnold, Co., Inc.	Boston, Mass.
81030	International Instruments Inc.	Orange, Conn.
81073	Grayhill Co.	LaGrange, Ill.
81095	Triad Transformer Corp.	Venice, Calif.
81312	Winchester Elec. Div. Litton Ind., Inc.	Oakville, Conn.
81349	Military Specification	. . . . . .
81415	Wilkor Products, Inc.	Cleveland, Ohio
81483	International Rectifier Corp.	El Segundo, Calif.
81541	Airpax Products Co., The	Cambridge, Mass.
81860	Barry Controls, Div. Barry Wright Corp.	Waterton, Mass.
82042	Carter Precision Electric Co.	Skokie, Ill.
82047	Sperti Faraday Inc., Copper Hewitt Electric Div.	Hoboken, N.J.
82142	Jeffers Electronics Division of Speer Carbon Co.	Du Bois, Pa.
82170	Fairchild Camera & Inst. Corp. Defense Prod. Division	Clifton, N.J.
82209	Maguire Industries, Inc.	Greenwich, Conn.
82219	Sylvania Electric Prod. Inc. Electronic Tube Division	Emporium, Pa
82376	Astron Corp.	East Newark, Harrison, N,J,
82389	Switchcraft, Inc.	Chicago, Ill.
82647	Metals & Controls Inc. Spencer Products	Attleboro, Mass.
82768	Phillips-Advance Control Co.	Joliet, Ill.
82866	Research Products Corp.	Madison, Wis.
82877	Rotron Mfg. Co., Inc.	Woodstock, N.Y.
82893	Vector Electronic Co.	Glendale, Calif.
83053	Western Washer Mfg. Co.	Los Angeles, Calif.
83058	Carr Fastener Co.	Cambridge, Mass.
83086	New Hampshire Ball Bearing, Inc.	Peterborough, N.H.
83125	General Instrument Corp., Capacitor Div.	Darlington, S.C.
83148	ITT Wire and Cable Div.	Los Angeles, Calif.
83186	Victory Engineering Corp.	Springfield, N.J.
83298	Bendix Corp., Red Bank Div.	Red Bank, N.J.
83315	Hubbell Corp.	Mundelein, Ill.
83330	Smith, Herman H., Inc.	Brooklyn, N.Y.
83385	Central Screw Co.	Chicago, Ill.
83501	Gavitt Wire and Cable Co Div. of Amerace Corp.	Brookfield, Mass.
83594	Burroughs Corp. Electronic Tube Div.	Plainfield, N.J.
83740	Eveready Div. National Carbon Div. Union Carbide Corp.	New York, N.Y.
83777	Model Eng. and Mfg., Inc.	Huntington, Ind.
83821	Loyd Scruggs Co.	Festus, Mo.
84171	Arco Electronics Ing	Great Neck, N.Y.
84396	A.J. Glesener Co., Inc.	San Francisco, Calif.
84411	TRW Capacitor Div.	Ogallala, Neb.
84970	Sarkes Tarzian, Inc.	Bloomington, Ind.
85454	Boonton Molding Company	Boonton, N.J.
85471	A.B. Boyd Co	San Francisco, Calif.
85474	R.M. Bracamonte & Co	San Francisco, Calif.
85660	Koiled Kords, Inc	Hamden, Conn.
85911	Seamless Rubber Co.	Chicago, Ill.
86197	Clifton Precision Products Co., Inc.	Clifton Heights, Pa.
86579	Precision Rubber Products Corp.	Dayton, Ohio
86684	Radio Corp. of Americal, Electronic Comp. & Devices Div.	Harrison, N.J.
87216	Philco Corporation (Lansdale Division)	Lansdale, Pa.
87473	Western Fibrous Glass Products Co.	San Francisco, Calif.
87664	Van Waters & Rogers Inc.	San Francisco, Calif.
87930	Tower Mfg. Corp.	Providence, R.I.
88140	Cutler-Hammer, Inc.	Lincoln, Ill.
88220	Gould-National Batteries, Inc.	St. Paul, Minn.
88421	Federal Telephone & Radio Corp.	Clifton, N.J.
88698	General Mills, Inc.	Buffalo, N.Y.
89231	Graybar Electric Co.	Oakland, Calif
89665	United Transformer Co.	Chicago, Ill
90179	US Rubber Co., Consumer Ind. & Plastics Prod. Div.	Passaic, N.J.
90970	Bearing Engineering Co.	San Francisco, Calif.
91260	Connor Spring Mfg. Co.	San Francisco, Calif.
91345	Miller Dial & Nameplate Co.	El Monte, Calif.
91418	Radio Materials Co.	Chicago, Ill
91506	Augat Inc.	Attleboro, Mass.
91637	Dale Electronics, Inc.	Columbus, Nebr.
91662	Elco Corp.	Willow Grove, Pa.
91737	Gremar Mfg. Co., Inc.	Wakefield, Mass.
91827	K F Development Co.	Redwood City, Calif.
91929	Honeywell Inc., Micro Switch Div.	Freeport, Ill
91961	Nahm-Bros. Spring Co.	Oakland, Calif.
92180	Tru-Connector Corp.	Peabody, Mass.
92367	Elgeet Optical Co. Inc.	Rochester, N.Y.
92196	Universal Industries, Inc.	City of Industry, Calif.
92607	Tensolite Insulated Wire Co., Inc.	Tarrytown, N.Y.
93332	Sylvania Electric Prod. Inc. Semiconductor Div.	Woburn, Mass.
93369	Robbins and Myers, Inc.	New York, N.Y.
93410	Stevens Mfg. Co., Inc.	Mansfield, Ohio
93788	Howard J. Smith Inc.	Port Monmouth, N.J.
93929	G.V. Controls	Livingston, N.J.
94137	General Cable Corp.	Bayonne, N.J.
94144	Raytheon Co., Comp. Div., Ind. Comp. Operations	Quincy, Mass.
94148	Scientific Electronics Products, Inc.	Loveland, Colo.
94154	Tung-Sol Electric, Inc.	Newark, N.J.
94197	Curtiss-Wright Corp. Electronics Div.	East Paterson, N.J.
94222	South Chester Corp.	Chester, Pa.
94310	Tru-Ohm Products Memcor Components Div.	Huntington, Ind.
94330	Wire Cloth Products, Inc.	Bellwood, Ill.
94682	Worcester Pressed Aluminum Corp.	Worcester, Mass.
94696	Magnecraft Electric Co.	Chicago, Ill.
95073	George A. Philbrick Researchers, Inc.	Boston, Mass.
95236	Allies Products Corp.	Miami, Fla.
95238	Continental Connector Corp.	Woodside, N.Y.
95263	Leecraft Mfg. Co., Inc.	Long Island, N.Y.
95264	Lerco Electronics, Inc.	Burbank, Calif.
95265	National Coil Co.	Sheridan, Wyo.
95275	Vitramon, Inc.	Bridgeport, Conn.
95348	Gordos Corp.	Bloomfield, N.J.
95354	Methode Mfg. Co.	Chicago, Ill.
95712	Dage Electric Co., Inc.	Franklin, Ind.
95984	Siemon Mfg. Co.	St. Charles, Ill.
95987	Weckesser Co.	Chicago, Ill.
96067	Huggins Laboratories	Sunnyvale, Calif.
96095	Hi-Q Div. of Aerovox Corp.	Olean, N.Y.
96256	Thordarson-Meissner Inc.	Mt. Carmel, Ill.
96296	Solar Manufacturing Co.	Los Angeles, Calif.
96330	Carlton Screw Co.	Chicago, Ill.
96341	Microwave Associates, Inc.	Burlington, Mass.
96501	Excel Transformer Co.	Oakland, Calif.
97464	Industrial Retaining Ring Co.	Irvington, N.J.
97539	Automatic & Precision Mfg.	Englewood, N.J.
97979	Reon Resistor Corp.	Yonkers, N.Y.
97983	Litton System Inc., Adler-Westrex Commun. Div.	New Rochelle, N.Y.
98141	R-Troncis, Inc.	Jamaica, N.Y.
98159	Rubber Teck, Inc.	Gardena, Calif.
98220	Francis L. Moseley	Pasadena, Calif.
98278	Microdot, Inc.	So. Pasadena, Calif.
98291	Sealectro Corp.	Mamaroneck, N.Y.
98731	General Mills Inc., Electronics Div.	Minneapolis, Minn.
98821	North Hills Electronics, Inc.	Glen Cove, N.Y.
98978	International Electronic Research Corp.	Burbank, Calif.
99109	Columbia Technical Corp.	New York, N.Y.
99313	Varian Associates	Palo Alto, Calif.
99515	Marshall Ind. Elect. Products Div.	San Marino, Calif.
99707	Control Switch Division, Controls Co. of America	El Segundo, Calif.
99800	Delevan Electronics Corp.	East Aurora, N.Y.
99848	Wilco Corporation	Indianapolis, Ind.
99934	Renbrandt, Inc.	Boston, Mass.
99942	Hoffman Electronics Corp. Semiconductor Div.	El Monte, Calif.
99957	Technology Instrument Corp. of Calif.	Newbury Park, Calif.

THE FOLLOWING HP VENDORS HAVE NO NUMBER ASSIGNED IN THE LATEST SUPPLEMENT TO THE FEDERAL SUPPLY CODE FOR MANUFACTURERS HANDBOOK.

0000F	Malco Tool and Die	Los Angeles, Calif.
0000M	Western Coil Div. of Automatic Ind., Inc.	Redwood City, Calif.
0000Z	Willow Leather Products Corp.	Newark, N.J.
000AA	British Radio Electronics Ltd.	Washington, D.C.
000AB	ETA	England
000BB	Precision Instrument Components Co.	Van Nuys, Calif.
000MM	Rubber Eng. & Development	Hayward, Calif.
000NN	A "N" D Mfg. Co.	San Jose, Calif.
000QQ	Cooltron	Oakland, Calif.
000WW	California Eastern Lab.	Burlington, Calif.
000YY	S.K. Smith Co.	Los Angeles, Calif.

From: FSC. Handbook Supplements
H4-1 Dated JULY 1965
H4-2 Dated NOV. 1962

APPENDIX

MANUAL CHANGES

This Manual applies directly to instruments with serial prefix, 543-. For serial 539-00120 and below make the changes indicated below. If the serial prefix on your instrument is not shown, either here or on a change sheet supplied with the manual, the correct information can be obtained from your nearest Hewlett-Packard Sales and Service Office (see list at rear of this manual).

For instruments serialed 539-00120 and below:
Add (in series with emitter of Q1): R128, 0812-0033, Fixed WW 7 ohm 3% 5W
CR20: Change hp Stock Number to 1902-0037

HEWLETT hp PACKARD

ELECTRONIC INSTRUMENTATION SALES AND SERVICE

UNITED STATES

ALABAMA
P.O. Box 4207
2003 Byrd Spring Road S.W.
Huntsville 35802
Tel: (205) 881-4591
TWX: 810-726-2204

ARIZONA
3009 North Scottsdale Road
Scottsdale 85251
Tel: (602) 945-7601
TWX: 910-950-1282

232 South Tucson Boulevard
Tucson 85716
Tel: (602) 623-2564
TWX: 910-952-1162

CALIFORNIA
3939 Lankershim Boulevard
North Hollywood 91604
Tel: (213) 877-1282
TWX: 910-499-2170

1101 Embarcadero Road
Palo Alto 94303
Tel: (415) 327-6500
TWX: 910-373-1280

2591 Carlsbad Avenue
Sacramento 95821
Tel: (916) 482-1463
TWX: 910-367-2092

1055 Shafter Street
San Diego 92106
Tel: (714) 223-8103
TWX: 910-335-2000

COLORADO
7965 East Prentice
Englewood 80110
Tel: (303) 771-3455
TWX: 910-935-0705

CONNECTICUT
508 Tolland Street
East Hartford 06108
Tel: (203) 289-9394
TWX: 710-425-3416

111 East Avenue
Norwalk 06851
Tel: (203) 853-1251
TWX: 710-468-3750

DELAWARE
3941 Kennett Pike
Wilmington 19807
Tel: (302) 655-6161
TWX: 510-666-2214

FLORIDA
Suite 106
9999 N.E. 2nd Avenue
Miami Shores 33138
Tel: (305) 758-3626
TWX: 810-848-7262

P.O. Box 20007
Herndon Station 32814
621 Commonwealth Avenue
Orlando
Tel: (305) 841-3970
TWX: 810-850-0113

P.O. Box 8128
Madeira Beach 33708
410 150th Avenue
St. Petersburg
Tel: (813) 391-0211
TWX: 810-863-0366

GEORGIA
P.O. Box 28234
2340 Interstate Parkway
Atlanta 30328
Tel: (404) 436-6181
TWX: 810-766-4890

ILLINOIS
5500 Howard Street
Skokie 60076
Tel: (312) 677-0400
TWX: 910-223-3613

INDIANA
4002 Meadows Drive
Indianapolis 46205
Tel: (317) 546-4891
TWX: 810-341-3263

LOUISIANA
P.O. Box 856
1942 Williams Boulevard
Kenner 70062
Tel: (504) 721-6201
TWX: 810-955-5524

MARYLAND
6707 Whitestone Road
Baltimore 21207
Tel: (301) 944-5400
TWX: 710-862-0850

P.O. Box 727
Twinbrook Station 20851
12303 Twinbrook Parkway
Rockville
Tel: (301) 427-7560
TWX: 710-828-9684

MASSACHUSETTS
Middlesex Turnpike
Burlington 01803
Tel: (617) 272-9000
TWX: 710-332-0382

MICHIGAN
24315 Northwestern Highway
Southfield 48075
Tel: (313) 353-9100
TWX: 810-232-1532

MINNESOTA
2459 University Avenue
St. Paul 55114
Tel: (612) 645-9461
TWX: 910-563-3734

MISSOURI
9208 Wyoming Place
Kansas City 64114
Tel: (816) 333-2445
TWX: 910-771-2087

2812 South Brentwood Blvd.
St. Louis 63144
Tel: (314) 644-0220
TWX: 910-760-1670

NEW JERSEY
391 Grand Avenue
Englewood 07631
Tel: (201) 567-3933
TWX: 710-991-9707

NEW MEXICO
P.O. Box 8366
Station C 87108
6501 Lomas Boulevard N.E.
Albuquerque
Tel: (505) 255-5586
TWX: 910-989-1665

156 Wyatt Drive
Las Cruces 88001
Tel: (505) 526-2485
TWX: 910-983-0550

NEW YORK
1702 Central Avenue
Albany 12205
Tel: (518) 869-8462

1219 Campville Road
Endicott 13760
Tel: (607) 754-0050
TWX: 510-252-0890

236 East 75th Street
New York 10021
Tel: (212) 879-2023
TWX: 710-581-4376

82 Washington Street
Poughkeepsie 12601
Tel: (914) 454-7330
TWX: 510-248-0012

39 Saginaw Drive
Rochester 14623
Tel: (716) 473-9500
TWX: 510-253-5981

1025 Northern Boulevard
Roslyn, Long Island 11576
Tel: (516) 869-8400
TWX: 510-223-0811

5858 East Molloy Road
Syracuse 13211
Tel: (315) 454-2486
TWX: 710-541-0482

NORTH CAROLINA
P.O. Box 5187
1923 North Main Street
High Point 27262
Tel: (919) 882-6873
TWX: 510-926-1516

OHIO
5579 Pearl Road
Cleveland 44129
Tel: (216) 884-9209
TWX: 810-421-8500

2460 South Dixie Drive
Dayton 45439
Tel: (513) 298-0351
TWX: 810-459-1925

OREGON
Westhills Mall, Suite 158
4475 S.W. Scholls Ferry Road
Portland 97225
Tel: (503) 292-9171
TWX: 910-464-6103

PENNSYLVANIA
2500 Moss Side Boulevard
Monroeville 15146
Tel: (412) 271-0724
TWX: 710-797-3650

144 Elizabeth Street
West Conshohocken 19428
Tel: (215) 248-1600, 828-6200
TWX: 510-660-8715

TEXAS
P.O. Box 7166
3605 Inwood Road
Dallas 75209
Tel: (214) 357-1881
TWX: 910-861-4081

P.O. Box 22813
4242 Richmond Avenue
Houston 77027
Tel: (713) 667-2407
TWX: 910-881-2645

GOVERNMENT CONTRACT OFFICE
225 Billy Mitchell Road
San Antonio 78226
Tel: (512) 434-4171
TWX: 910-871-1170

UTAH
2890 South Main Street
Salt Lake City 84115
Tel: (801) 486-8166
TWX: 910-925-5681

VIRGINIA
P.O. Box 6514
2111 Spencer Road
Richmond 23230
Tel: (703) 282-5451
TWX: 710-956-0157

WASHINGTON
11656 N.E. Eighth Street
Bellevue 98004
Tel: (206) 454-3971
TWX: 910-443-2303

FOR AREAS NOT LISTED, CONTACT: Hewlett-Packard; 1501 Page Mill Road; Palo Alto, California 94304; Tel: (415) 326-7000; TWX: 910-373-1267; Telex: 34-8461

CANADA

ALBERTA
10010 - 105th Street
Edmonton
Tel: (403) 424-0718
TWX: 610-831-2431

BRITISH COLUMBIA
Hewlett-Packard (Canada) Ltd.
2184 West Broadway
Vancouver
Tel: (604) 738-7520
TWX: 610-922-5050

NOVA SCOTIA
7001 Mumford Road
Suite 356
Halifax
Tel: (902) 455-0511
TWX: 610-271-4482

ONTARIO
Hewlett-Packard (Canada) Ltd.
880 Lady Ellen Place
Ottawa 3
Tel: (613) 722-4223
TWX: 610-562-1952

Hewlett-Packard (Canada) Ltd.
1415 Lawrence Avenue West
Toronto
Tel: (416) 249-9196
TWX: 610-492-2382

QUEBEC
Hewlett-Packard (Canada) Ltd.
275 Hymus Boulevard
Pointe Claire
Tel: (514) 697-4232
TWX: 610-422-3022
Telex: 01-2819

FOR AREAS NOT LISTED, CONTACT: Hewlett-Packard Inter-Americas; 1501 Page Mill Road; Palo Alto, Calif. 94304; Tel: (415) 326-7000; TWX: 910-373-1267; Telex: 034-8461; Cable: HEWPACK Palo Alto

---

CENTRAL AND SOUTH AMERICA

ARGENTINA
Mauricio A. Suárez
Telecomunicaciones
Carlos Calvo 224
Buenos Aires
Tel: 30-6312, 34-9087
Cable: TELEPILOT Buenos Aires

BRAZIL
Ciental, Importacao e
Comércio Ltda.
Avenida 13 de Maio, 13-22° andar
Rio de Janeiro G.B.
Tel: 42-9483

Ciental, Importacao e
Comércio Ltda.
Rua Des. Eliseu Guilherme, 62
Sao Paulo 8
Tel: 70-2318
Cable: CIENTALCO, Sao Paulo

CHILE
Héctor Calcagni
Casilla 13942
Santiago
Tel: 490.505, 393.119

COLOMBIA
Instrumentacion
Henrik A. Langebaek & Cia. Ltda.
Cra. 7A N° 48-51/59
Apartado Aereo 6287
Bogota, 1 D.E.
Tel: 45-78-06, 45-55-46
Cable: AARIS Bogota

COSTA RICA
Lic. Alfredo Gallegos Gurdián
Apartado 3243
San José
Tel: 21-86-13
Cable: GALGUR San José

ECUADOR
Laboratorios de Radio-Ingenieria
Calle Guayaquil 1246
Post Office Box 3199
Quito
Tel: 12496
Cable: HORVATH Quito

EL SALVADOR
Electrónica
27 Avenida Norte 1133
Apartado Postal 1589
San Salvador
Tel: 25-74-50
Cable: ELECTRONICA
San Salvador

GUATEMALA
Olander Associates Latin America
Apartado 1226
7a. Calle, 0-22, Zona 1
Guatemala City
Tel: 22812
Cable: OLALA Guatemala City

MEXICO
Hewlett-Packard Mexicana,
S.A. de C.V.
Eugenia 408, Dept. 1
Mexico 12, D.F.
Tel: 43-03-79

NICARAGUA
Roberto Terán G.
Edificio Terán
Apartado Postal 689
Managua
Tel: 3451, 3452
Cable: ROTERAN Managua

PANAMA
Electrónica Balboa, S.A.
P.O. Box 4929
Ave. Manuel Espinosa No. 13-50
Bldg. Alina
Panama City
Tel: 30833
Cable: ELECTRON Panama City

PERU
Fernando Ezeta B.
Av. Petit Thouars 4719
Miraflores
Casilla 3061
Lima
Tel: 50346
Cable: FEPERU Lima

PUERTO RICO
San Juan Electronics, Inc.
P.O. Box 5167
Ponce de León 150, Stop 3
Puerta de Tierra Santa
San Juan 00906
Tel: (809) 725-3342
Cable: SATRONICS San Juan

URUGUAY
Pablo Ferrando
S.A. Comercial e Industrial
Avenida Italia 2877
Casilla de Correo 370
Montevideo
Tel: 40-3102
Cable: RADIUM Montevideo

VENEZUELA
Citec, C.A.
Edif. Arisan-Of. #4
Avda. Francisco de Miranda
Apartado del Este 10934 Chacaito
Caracas
Tel: 71.88.05
Cable: CITECAL Caracas

FOR AREAS NOT LISTED, CONTACT: Hewlett-Packard Inter-Americas; 1501 Page Mill Road; Palo Alto, Calif. 94304; Tel: (415) 326-7000; TWX: 910-373-1267; Telex: 034-8461; Cable: HEWPACK Palo Alto

5/67

ELECTRONIC INSTRUMENTATION SALES AND SERVICE
EUROPE, AFRICA, ASIA, AUSTRALIA

EUROPE

AUSTRIA
Unilabor GmbH
Wissenschaftliche Instrumente
Rummelhardtgasse 6/3
P.O. Box 33
Vienna IX/71
Tel: 426 181
Cable: LABORINSTRUMENT Vienna

BELGIUM
Hewlett-Packard Benelux S.A.
348 Boulevard du Souverain
Brussels 16
Tel: 72 22 40
Cable: PALOBEN Brussels
Telex: 23 494

DENMARK
Hewlett-Packard A/S
Langebjerg 6
2850 **Naerum**
Tel: 01 80 40 40
Cable: HEWPACK AS
Telex: 66 40

FINLAND
Hewlett-Packard Oy
Gyldenintie 3
Helsinki 20
Tel: 67 35 38
Telex: 12-1563

FRANCE
Hewlett-Packard France
150 Boulevard Masséna
75 **Paris** 13e
Tel: 707 97 19
Cable: HEWPACK Paris
Telex: 25048

Hewlett-Packard France
4, quai des Etroits
69 **Lyon** 6e
Tel: 52 35 66
Telex: 31617

GERMANY
Hewlett-Packard Vertriebs-GmbH
Lietzenburger Strasse 30
1 **Berlin** W.30
Tel: 24 86 36

Hewlett-Packard Vertriebs-GmbH
Herrenberger Strasse 110
703 **Böblingen,** Württemberg
Tel: 07031-6971
Cable: HEPAG Böblingen
Telex: 72 65 739

Hewlett-Packard Vertriebs-GmbH
Achenbachstrasse 15
4 **Düsseldorf** 1
Tel: 68 52 58/59
Telex: 85 86 533

Hewlett-Packard Vertriebs-GmbH
Kurhessenstrasse 95
6 **Frankfurt** 50
Tel: 52 00 36
Cable: HEWPACKSA Frankfurt
Telex: 41 32 49

Hewlett-Packard Vertriebs-GmbH
Beim Strohhause 26
2 **Hamburg** 1
Tel: 24 05 51/52
Cable: HEWPACKSA Hamburg
Telex: 21 53 32

Hewlett-Packard Vertriebs-GmbH
Reginfriedstrasse 13
8 **Munich** 9
Tel: 69 51 21/22
Cable: HEWPACKSA Munich
Telex: 52 49 85

GREECE
Kostas Karayannis
18, Ermou Street
Athens 126
Tel: 230 301
Cable: RAKAR Athens

IRELAND
Hewlett-Packard Ltd.
224 Bath Road
Slough, Bucks, England
Tel: Slough 28406-9, 29468-9
Cable: HEWPIE Slough
Telex: 84413

ITALY
Hewlett-Packard Italiana S.p.A.
Viale Lunigiana 46
20125 **Milan**
Tel: 69 15 84
Cable: HEWPACKIT Milan
Telex: 32046

Hewlett-Packard Italiana S.p.A.
Palazzo Italia
Piazza Marconi 25
00144 **Rome-Eur**
Tel: 591 25 44
Cable: HEWPACKIT Rome

NETHERLANDS
Hewlett-Packard Benelux N.V.
De Boelelaan 1043
Amsterdam, Z.2
Tel: 42 77 77
Cable: PALOBEN Amsterdam
Telex: 13 216

NORWAY
Hewlett-Packard Norge A/S
Nesveien 13
Haslum
Tel: 53 83 60
Cable: HEWPACK Oslo
Telex: 6621

PORTUGAL
Telectra
Rua Rodrigo da Fonseca 103
P.O. Box 2531
Lisbon 1
Tel: 68 60 72
Cable: TELECTRA Lisbon
Telex: 1598

SPAIN
Ataio Ingenieros
Enrique Larreta 12
Madrid, 16
Tel: 235 43 44
Cable: TELEATAIO Madrid
Telex: 2 72 49

Ataio Ingenieros
Urgel, 259
Barcelona, 11
Tel: 230 69 88

SWEDEN
HP Instrument AB
Svetsarvägen 7
Fack
Solna
Tel: (08) 98 12 50
Cable: MEASUREMENTS Stockholm
Telex: 10 721

HP Instrument AB
Hagakersgatan 7
Mölndal
Tel: 031 27 68 00

SWITZERLAND
HEWPAK AG
Zürcherstrasse 20
8952 Schlieren **Zurich**
Tel: (051) 98 18 21
Cable: HEWPACKAG Zurich
Telex: 53933

HEWPAK A.G.
54 Route des Acacias
1211 **Geneva** 24
Tel: 43 79 29
Telex: 2 24 86

TURKEY
Telekom Engineering Bureau
P.O. Box 376 Galata
Istanbul
Tel: 49 40 40
Cable: TELEMATION Istanbul

UNITED KINGDOM
Hewlett-Packard Ltd.
224 Bath Road
Slough, Bucks
Tel: Slough 28406-9, 29486-9
Cable: HEWPIE Slough
Telex: 84413

YUGOSLAVIA
Belram S.A.
83 Avenue des Mimosas
Brussels 15, Belgium
Tel: 34 33 32
Cable: BELRAMEL Brussels
Telex: 21790

FOR AREAS NOT LISTED, CONTACT:
Hewlett-Packard S.A.
54 Route des Acacias
1211 **Geneva,** Switzerland
Tel: (022) 42 81 50
Telex: 2.24.86
Cable: HEWPACKSA Geneva

AFRICA, ASIA, AUSTRALIA

AUSTRALIA
Hewlett-Packard Australia Pty. Ltd.
22-26 Weir Street
Glen Iris 3146
Victoria
Tel: 20 1371 (4 lines)
Cable: HEWPARD Melbourne

Hewlett-Packard Australia Pty. Ltd.
61 Alexander Street
Crows Nest 2065
New South Wales
Tel: 43.7866
Cable: HEWPARD Sydney

Hewlett-Packard Australia Pty. Ltd.
97 Churchill Road
Prospect 5082
South Australia
Tel: 65.2366
Cable: HEWPACK Adelaide

CEYLON
United Electricals Ltd.
P.O. Box 681
Yahala Building
Staples Street
Colombo 2
Tel: 5496
Cable: HOTPOINT Colombo

ETHIOPIA
African Salespower & Agency
Private Ltd., Co.
P.O. Box 718
58/59 Cunningham Street
Addis Ababa
Tel: 12285
Cable: ASACO Addisababa

HONG KONG
Schmidt & Co. (Hong Kong) Ltd.
P.O. Box 297
1511, Prince's Building
15th Floor
10, Chater Road
Hong Kong
Tel: 240168, 232735
Cable: SCHMIDTCO Hong Kong

INDIA
The Scientific Instrument Co., Ld.
6, Tej Bahadur Sapru Road
Allahabad 1
Tel: 2451
Cable: SICO Allahabad

The Scientific Instrument Co., Ld.
240, Dr. Dadabhai Naoroji Road
Bombay 1
Tel: 26-2642
Cable: SICO Bombay

The Scientific Instrument Co., Ld.
11, Esplanade East
Calcutta 1
Tel: 23-4129
Cable: SICO Calcutta

The Scientific Instrument Co., Ld.
30, Mount Road
Madras 2
Tel: 86339
Cable: SICO Madras

The Scientific Instrument Co., Ld.
B-7, Ajmeri Gate Extn.
New Delhi 1
Tel: 27-1053
Cable: SICO New Delhi

IRAN
Telecom, Ltd.
P.O. Box 1812
240 Kh. Saba Shomali
Teheran
Tel: 48111, 43850
Cable: BASCOM Teheran

ISRAEL
Electronics & Engineering
Division of Motorola Israel Ltd.
16, Kremenetski Street
Tel-Aviv
Tel: 35021 (four lines)
Cable: BASTEL Tel-Aviv

JAPAN
Yokogawa-Hewlett-Packard Ltd.
Nisei Ibaragi Bldg.
2-2-8, Kasuga
Ibaragi-shi
Osaka
Tel: 0726-23-1641

Yokogawa-Hewlett-Packard Ltd.
Ito Building
No. 59, Kotori-cho
Nakamura-ku, **Nagoya City**
Tel: 551-0215

Yokogawa-Hewlett-Packard Ltd.
Ohashi Building
No. 59, 1-chome, Yoyogi
Shibuya-ku, **Tokyo**
Tel: 370-2281
Telex: YHPMARKET TOK 23-724

KENYA
R. J. Tilbury Ltd.
P.O. Box 2754
Suite 517-518
Hotel Ambassadeur
Nairobi
Tel: 25670, 26803, 68206, 58196
Cable: ARJAYTEE Nairobi

KOREA
American Trading Co., Korea, Ltd.
Seoul P.O. Box 1103
112-35 Sokong-Dong
Jung-ku, **Seoul**
Tel: 3,7049, 3,7613
Cable: AMTRACO Seoul

LEBANON
Constantin E. Macridis
Clemenceau Street
Clemenceau Center
Beirut
Tel: 220846
Cable: ELECTRONUCLEAR Beirut

MALAYSIA
Mecomb Malaysia Ltd.
2 Lorong 13-6A
Section 13
Petaling Jaya, **Selangor**
Cable: MECOMB Kuala Lumpur

NEW ZEALAND
Hewlett-Packard (N.Z.) Ltd.
32-34 Kent Terrace
P.O. Box 9443
Wellington, N.Z.
Tel: 56-409
Cable: HEWPACK Wellington

PAKISTAN (EAST)
Mushko & Company, Ltd.
31, Jinnah Avenue
Dacca
Tel: 80058
Cable: NEWDEAL Dacca

PAKISTAN (WEST)
Mushko & Company, Ltd.
Oosman Chambers
Victoria Road
Karachi 3
Tel: 51027, 52927
Cable: COOPERATOR Karachi

SINGAPORE
Mechanical & Combustion
Engineering Company Ltd.
9, Jalan Kilang
Singapore 3
Tel: 642361-3
Cable: MECOMB Singapore

SOUTH AFRICA
F. H. Flanter & Co. (Pty.), Ltd.
Hill House
43 Somerset Road
Cape Town
Tel: 2-9711
Cable: AUTOPHONE Cape Town
Telex: 7038CT

F. H. Flanter & Co. (Pty.), Ltd.
607, Pharmacy House
80 Jorissen Street
Braamfontein, **Johannesburg**
Tel: 724-4172
Telex: 0026 JHB

TAIWAN
Hwa Sheng Electronic Co., Ltd.
P.O. Box 1558
21 Nanking West Road
Taipei
Tel: 46076, 45936, 48661
Cable: VICTRONIX Taipei

THAILAND
The International Engineering
Co., Ltd.
P.O. Box 39
614 Sukhumvit Road
Bangkok
Tel: 910722 (7 lines)
Cable: GYSOM Bangkok

VIETNAM
Landis Brothers & Company, Inc.
P.O. Box: H-3
216, Hien-Vuong
Saigon
Tel: 20.805
Cable: LANBROCOMP Saigon

ZAMBIA
R. J. Tilbury (Zambia) Ltd.
P.O. Box 2792
Lusaka
Zambia, Central Africa

FOR AREAS NOT LISTED, CONTACT:
Hewlett-Packard Export Marketing
1501 Page Mill Road
Palo Alto, California 94304
Tel: (415) 326-7000
TWX: 910-373-1267
Telex: 034-8461
Cable: HEWPACK Palo Alto

12/67

HEWLETT hp PACKARD

PRINTED IN U.S.A.